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Psyllids (Hemiptera: Psylloidea) associated with *Ficus vallis-choudae* (Moraceae) in southern Cameroon: taxonomy and biology

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Abstract: *Homotoma chlamydodora* Hollis & Bromfield, 1989 (Homotomidae) and *Pauropsylla tatrichea* Hollis, 1984 (Triozidae) are two poorly known psyllid species that develop on *Ficus vallis-choudae*. Based on material collected within the framework of biodiversity studies of psyllids (Hemiptera: Psylloidea) associated with *Ficus* spp. (Moraceae) in Cameroon, the taxonomy of the two psyllid species is revised and information on the biology is provided. In particular the previously unknown immatures of both species and the male of *P. tatrichea* are described and illustrated here. A tubercular process on the mesocoxa of *P. tatrichea*, a putative autapomorphy of *Pauropsylla* Rübsaamen, 1899 is described here for the first time. Both species are polyvoltine with overlapping generations. Immatures of *H. chlamydodora* develop under the stipules whereas those of *P. tatrichea* induce pit galls on the leaves. Both species appear to be restricted to *Ficus vallis-choudae*, at least locally.

Keywords: Homotomidae - Triozidae - *Homotoma chlamydodora* - *Pauropsylla tatrichea* - waxy pit-galls - buds.

INTRODUCTION

Non-wood forest products (NWFPs) play an important role in the everyday life of rural people in tropical countries around the world (Sorrenti, 2017). NWFPs provide food that helps reduce the shortages suffered during the 'hunger periods' of the agricultural cycle (Arnold, 2002). There is also increasing evidence that these foods are of great importance for the dietary quality of people in close proximity to forests, especially in communities with poor access to markets (Rowland *et al.*, 2016). Some NWFPs are sold in local markets, which stimulates the rural economy, but with the negative effect that, in order to maximize profits, harvesting methods are generally not sustainable. In order to protect these valuable resources, the participative domestication tried and tested by the ICRAF (World Agroforestry Centre) in Cameroon is a possible way (Tsobeng *et al.*, 2016). When trying to domesticate wild plants, insects can become a problem and sometimes even prevent this endeavour. Whereas there is a lot of literature on insect pests on cash crops, virtually nothing is known about insect communities of plants considered NWFPs. The tropical African fig *Ficus vallis-choudae* is such an example.

From Cameroon, 62 *Ficus* species have been recorded (van Noort & Rasplus, 2020), some of which are components of local agrarian systems (Gautier, 1996). These fig species are infested by various hemipterans including psyllids, viz. species of *Homotoma* Guérin-Méneville, 1844 (Homotomidae) and *Pauropsylla* Rübsaamen, 1899 (Triozidae). *Homotoma* comprises 33 species worldwide (2 in the Palaearctic Region, 4 in the Afrotropical Region, 23 in the Oriental Region and 4 in the Australo-Oriental Region), all associated with *Ficus* species (Burckhardt *et al.*, 2018). The tropical and subtropical *Pauropsylla* comprises 26 Old World species associated with *Ficus* (Burckhardt *et al.*, 2018) and two undescribed species in the New World (Brown & Hodkinson, 1988). Apart from their original descriptions based upon limited material (Hollis, 1984; Hollis & Broomfield, 1989), little is known about the Afrotropical species of both genera, such as host range, immature morphology or ecology.

To study the taxonomy, diversity and biology of psyllids on local *Ficus* species, surveys were undertaken by members of the Laboratory of Zoology of the University of Yaoundé I (LZUY) in southern Cameroon. Two

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of the observed species, *Homotoma eastopi* Hollis & Broomfield, 1989 and *Pauropsylla trichaeta* Hollis, 1984 are oligophagous on a number of fig species (Aléné *et al.*, 2014). Another two species, viz. *Homotoma chlamydodora* Hollis & Bromfield, 1989 and *Pauropsylla tatrichea* Hollis, 1984, appear to be locally restricted to a single host species, viz. *Ficus vallis-choudae*. This is a shrub or small tree of 18-30 m height. The fruits are edible and the pulp of the fruits is much appreciated by local people. Among the edible figs in Cameroon, these are the largest, the best tasting and the most used, as they are similar to common figs (Vivien & Faure, 1996).

Homotoma chlamydodora is widely distributed throughout the Afrotropical region (Angola, Burundi, Cameroon, Kenya, Nigeria, South Africa, Tanzania and Uganda) and adults were collected on *Ficus natalensis*, *F. petersii* [regarded as synonym of *F. thonningii* by WFO (2020) but as good species by van Noort & Rasplus (2020)] and *F. thonningii* (Hollis & Broomfield, 1989) but the immatures were not previously known. *Pauropsylla tatrichea* was described from three females from Cameroon and the Ivory Coast (Hollis, 1984) without additional information.

The present study describes the previously unknown last instar immatures and supplements the descriptions of

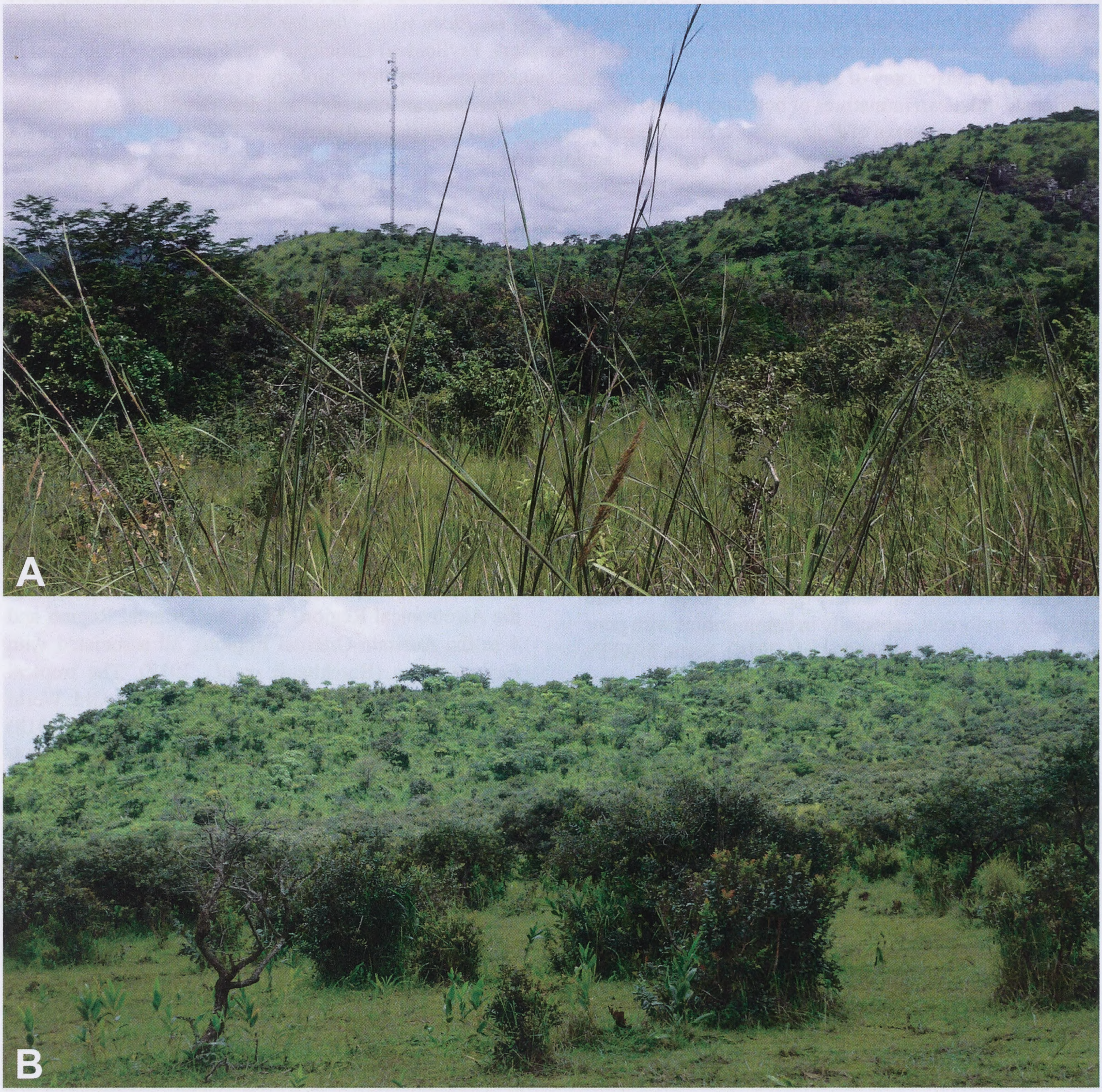


Fig. 1. Study sites. (A) Bapé (Bafia). (B) Tchouffa (Koutaba).

the adults, in particular the previously unknown male of *P. tatrichea*. Information is also provided on the biology of the two psyllids species.

MATERIAL AND METHODS

Field observations and samplings of psyllids were carried out on two sites, Bapé (04°49′25″ N, 11°10′35″ E; 610 m a.s.l.), a neighbourhood of Bafia (Centre Region of Cameroon), and Tchouffa (05°39′45″ N, 10°47′25″ E; 1200 m a.s.l.), a neighbourhood of Koutaba (West Region of Cameroon). The site at Bapé (Fig. 1A), with an annual mean temperature of 25.2 °C (20 °C min., 33 °C max.), is characterized by a tropical bimodal rainfall regime with a long dry season from mid-November to early March, a short rainy season from mid-March to early June, a short dry season from mid-June to late August and a long rainy season from early September to mid-November. The vegetation is bushy savannah. The site at Koutaba (Fig. 1B), with an annual mean temperature of 19.5 °C (16.5 °C min., 23.1 °C max.) undergoes a highland tropical unimodal rainfall regime with a short dry season from November to February and a long rainy season from March to October. The vegetation is shrubby and grassy savannah. In both sites, the savannah usually dries off during the dry season and regularly suffers from bush fires set for plantations or pasture and/or hunting. Potential psyllid feeding sites on host plants were carefully examined monthly, by direct visual observations, during a year from October 2015 to October 2016. The *Ficus* species sampled are listed in Table 1. The *Ficus* plants were identified in the field and, in case of incertitude, samples were collected and brought to the National Herbarium in Yaoundé for confirmation. Psyllids encountered were collected and kept alive or fixed in 75% ethanol for further study at the Laboratory of Zoology of the University of Yaoundé I (LZUY).

In the laboratory, samples were sorted and preserved in 75% ethanol in vials stored in a freezer, or mounted dry or on slides. Vouchers are deposited in the collections of the LZUY and the Naturhistorisches Museum Basel, Switzerland (NHMB). Photographs were taken from dissected and slide-mounted specimens at the "Unité Mixte de Recherche (UMR)" of the "Centre de Biologie pour la Gestion des Populations (CBGP)" – "Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)" at Montpellier (France) and NHMB using a compound microscope (Leica DMLB) and an auto-montage device (Keyence). Drawings and measurements were taken from slide-mounted and ethanol-preserved specimens at the LZUY (Olympus microscope) and NHMB (Leica DMLB microscope). The morphological terminology used here is combined from Hollis (1984) and Ossiannilsson (1992).

TAXONOMY

Homotoma chlamydodora Hollis & Broomfield, 1989

Figs 2, 3, 7C-E

Material examined: LZUY, NHMB NMB-PSYLL0006885 to NMB-PSYLL0006889; 35 males, 39 females, 74 immatures; Cameroon, West Region, Tchouffa, near Koutaba, 5°39′45″ N 10°47′25″ E, 1200 m; 11.xi.2015; on apical buds of *Ficus vallis-choudae*; D.C. Aléné, #PF2; dry and slide mounted, and stored in 70% ethanol.

Description of fifth instar immature (Fig. 2)

Coloration: Body with light brown sclerites, antennae, wing pads and caudal plate; membrane milky white; eyes pink (Fig. 2A).

Structure: Body dorso-ventrally flattened, oval, 2-3 mm long and 1.5-1.9 mm wide (Fig. 2A). Antenna (Fig. 2B) short, thick, three-segmented; segment 1 wider than the

Table 1. *Ficus* species examined at the two study sites.

Ficus species	Bafia (Bapé)	Koutaba (Tchouffa)
Ficus bubu Warb.	x	
Ficus exasperata Vahl	x	x
Ficus gnaphalocarpa (Miq.) Steud. ex Miq.		x
Ficus mucuso Welw. ex Ficalho	x	
Ficus ?*polita* Vahl	x	
Ficus sur Forssk.	x	x
Ficus sycomorus L.	x	x
Ficus ?*thonningii* Blume	x	
Ficus trichopoda Baker	x	x
Ficus vallis-choudae Delile	x	x
Ficus sp. 1	x	
Ficus sp. 2	x	

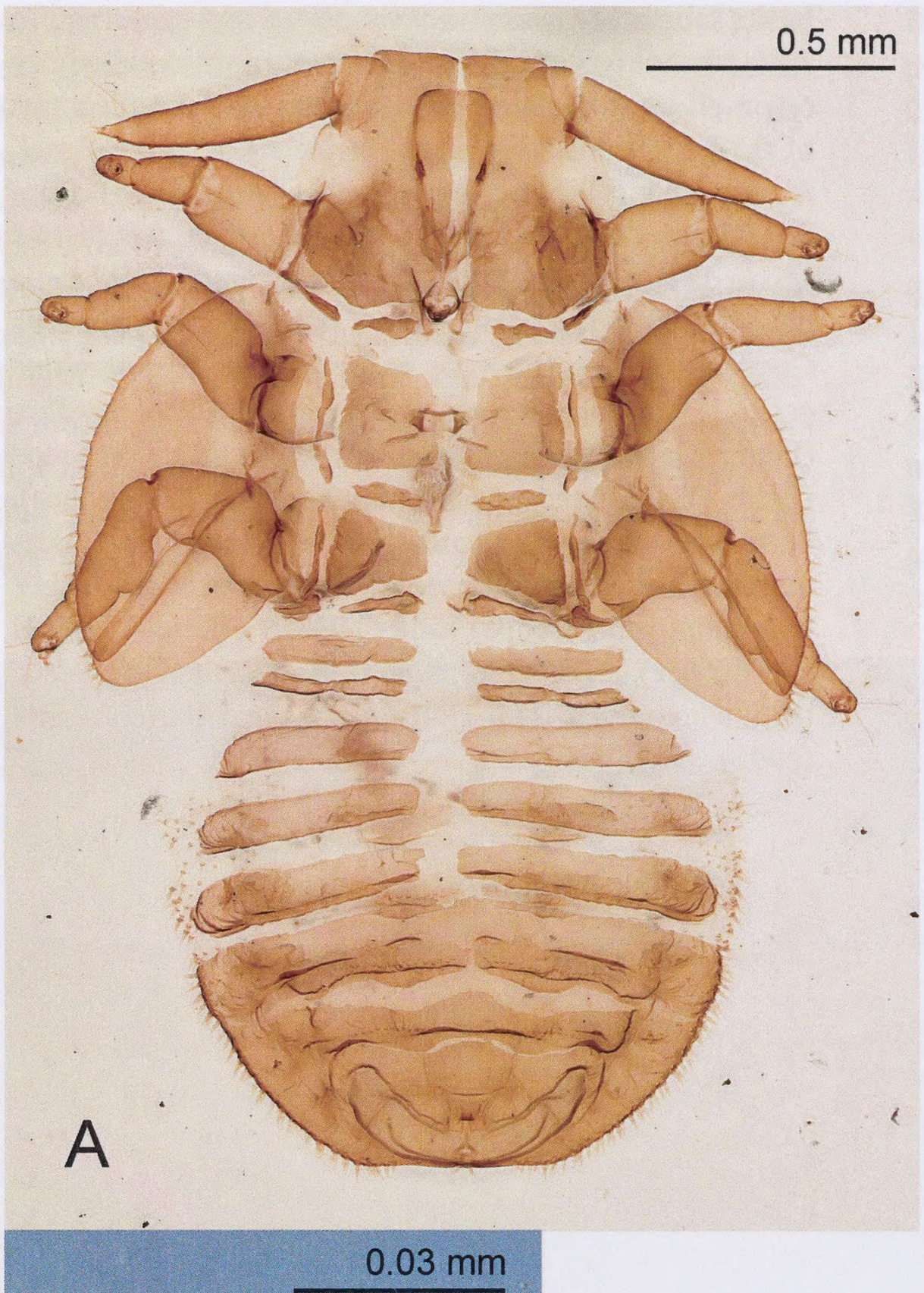


Fig. 2. Fifth instar immature of *Homotoma chlamydodora*. (A) Habitus, cleared specimen, in dorsal view. (B) Antenna. (C) Wing pads. (D) Tarsal apex with claws and arolium. (E) Caudal plate.

other two segments, 1.5 times wider than long, 2.5 times longer than segment 2, and bearing one moderately long seta on the dorsal side; segment 2 almost 3 times wider than long; segment 3 very weakly widening basally and tapering apically, 3.5-4.0 times longer than segment 1, bearing four small rhinaria ventrally and covered in moderately long and short setae, with two strong, unequal terminal setae. Dorsal cephalo-prothoracic sclerite well-developed, margined caudally by two narrow sclerites, one transverse submedian and one oblique submarginal. Meso and metanotum consisting each of three sclerites, a large trapezoidal one in antero-median position, a longitudinal narrow elongate one between wing pad and large sclerite, and a transverse narrow elongate

one caudad to the large sclerite. Forewing pad almost 2.5 times longer than wide, lacking humeral lobe, margin bearing usually simple setae in basal quarter and pointed lanceolate setae or indistinct sectasetae in apical three quarters (Fig. 2C). Legs four-segmented. Metatibiotarsus strongly constricted just beyond the middle on the underside and bearing two to three long setae on the upper side. Metatarsus bearing sparse short simple setae dorsally and two long setae above the claws; tarsal arolium almost triangular, slightly longer than claws, without petiole but with unguitractor (Fig. 2D). Abdomen rounded, with five tergites proximal to caudal plate; the second one being the narrowest; these sclerites scarcely covered in short simple setae with marginal long setae; marginal and sub-marginal membrane near the two last sclerites densely covered in moderately long simple setae and lanceolate setae or indistinct sectasetae. Caudal plate more than twice wider than long, truncate caudally; densely bordered with pointed sectasetae and a few simple long setae, sparser caudally with one long simple seta and two sectasetae on either side of body axis (Fig. 2E). Anus ventral; outer circumanal ring irregularly, narrowly oval, consisting of several rows of pores.

Description of adult (Fig. 3)

Coloration: Body light-brown; head darker; antennal flagellum dark-brown to black (Fig. 3A). Forewing (Fig. 3G) hyaline, with dark veins and indistinct pattern, consisting of a narrow light brown band along apical third and a broader darker band in apical two thirds along anal margin; hindwing hyaline and uncoloured.

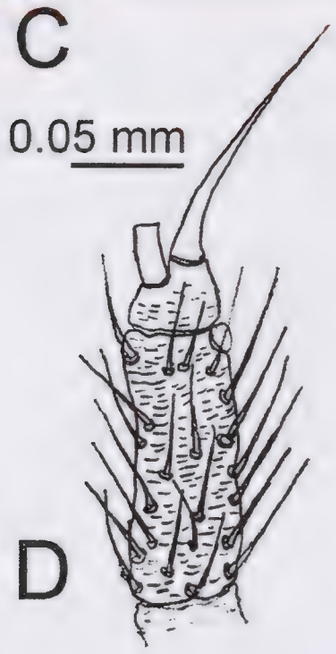
Structure: Described by Hollis & Broomfield (1989: 160, 161, figs 68, 69, 103, 104).

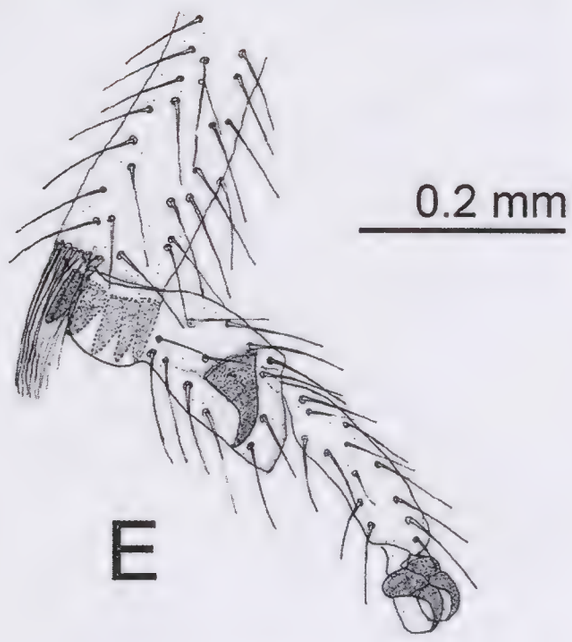
Body length (measured from anterior head margin to tip of forewings when folded over the body) in specimens from Cameroon 3.5-4.0 mm in male and 4.0-4.5 mm in female; body width (measured across mesoscutum between insertions of forewings) 1.5-2.0 mm in male and 1.7-2.2 mm in female. Integument of head and thorax moderately densely covered in long setae. Head almost as wide as mesoscutum, weakly inclined from longitudinal body axis, bearing long setae dorsally and ventrally (Fig. 3B); lateral margins of vertex weakly rounded caudally, occipital margin angular; vertex divided by a deep median suture. Compound eyes hemispherical. Median ocellus in front on oblong frons; lateral ocelli near hind margin of vertex. Genae weakly swollen, extending to antennal sockets, giving the head a cleft appearance. Antennae (Fig. 3C) thick, long (2.2-2.3 mm in male, 2.4-2.5 mm in female), densely setose; flagellum circular in cross-section with eight flagellomeres; flagellomere 1 about twice as long as 2; flagellomere 8 very short, less than half as long as 7, bearing two terminal setae, one short, truncate and one long, pointed, at least 5 times longer than shorter one (Fig. 3D); with each a subapical rhinarium on flagellomeres 2, 4, 6, and 7. Thorax weakly arched in profile. Pronotum visible from above, without anterior tubercles. Forewing 3.2-4.5 mm long, oblong, 3.3 times as long as wide, subacute apically (Fig. 3G); vein R+M+Cu at least twice as long as R and more than twice as long as M+Cu; vein Cu almost twice as long as M+Cu and Cu_{1b}, cu_1 cell elongate with a value of 2.5, M 3.5 times as long as M_{1+2} and twice as long as M_{3+4}; R 1.3 times as long as R_1, Rs weakly curved towards fore margin and 4.5 times as long as R. Hindwing almost as long as the forewing, widest medially, narrowly rounded apically; veins R and M with common stem, vein Cu indistinct at base; costal vein with 3-4 pointed setae proximal to costal break, setae distal to costal break divided into two groups with 1-3 pointed setae adjacent to costal break and 4-5 hook-shaped setae in the middle in addition to hamulus at the end of vein (Fig. 3H). Metacoxa bearing a well-developed thumb-like meracanthus (Fig. 3F); metatibia lacking basal spine, with 5 densely spaced, inner apical spurs (Fig. 3E), metabasitarsus with a single outer lateral spur (Fig. 3E). Male terminalia (Fig. 3I) with bipartite proctiger; proximal segment narrow in basal third, broad in apical two thirds with broadly rounded posterior lobe, in profile; distal portion tubular, inserted between the posterior lobes of proximal segment; sparsely covered in moderately long setae. Paramere in profile lamellar, weakly curved; inner surface with a sub-marginal rim in apical third and a sclerotized tooth in apical third near fore margin, and moderately long marginal setae (Fig. 3J). Proximal segment of aedeagus basally strongly curved, swollen medially; distal segment of aedeagus clavate with sclerotized end-tube of ductus ejaculatorius short and weakly sinuate (Fig. 3K). Female terminalia (Fig. 3L) cuneate. Dorsal margin of proctiger almost straight, narrowly rounded apically, beset with moderately long setae and an irregular longitudinal row of submedian setae in apical half on either side; circumanal ring oval, consisting of two unequal rows of pores. Subgenital plate pointed apically, ventral margin with a bend in the middle. Dorsal and ventral valvulae weakly curved (Fig. 3M).

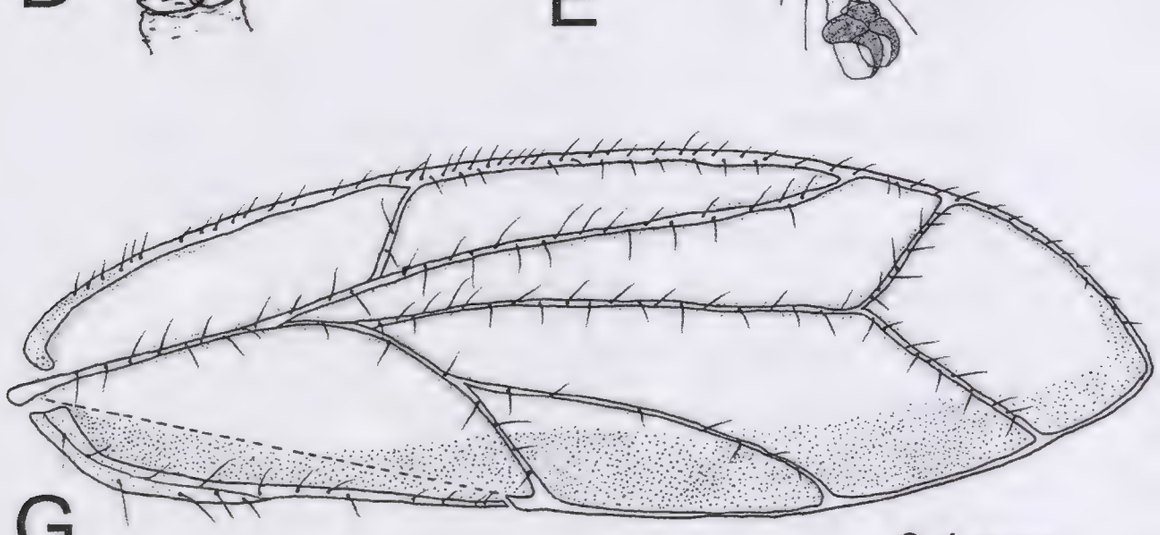
***Pauropsylla tatrichea* Hollis, 1984**

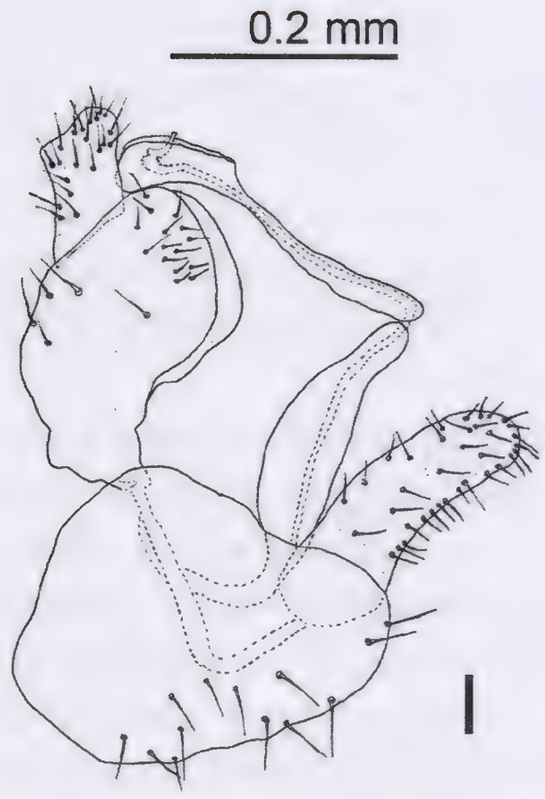
Figs 4-6, 7F, G

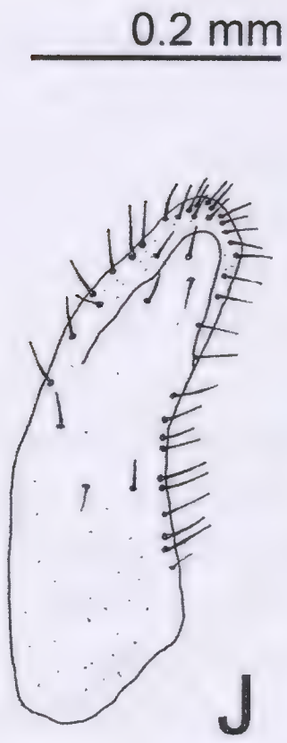
Material examined: LZUY, NHMB NMB-PSYLL0006890, NMB-PSYLL0006891; 41 males, 40 females, 54 immatures; Cameroon, West Region, Tchouffa, near Koutaba, 5°39′45″ N 10°47′25″ E, 1200 m; 11.xi.2015; in pit galls on leaves of *Ficus vallis-choudae*; D.C. Aléné, #PF3; dry and slide mounted, and stored in 70% ethanol. – NHMB NMB-PSYLL0006892 to NMB-PSYLL0006897; 17 males, 16 females, 41 immatures, 26 skins; Cameroon, Centre Region, Bapé, near Bafia, 4°49′25″ N 11°10′35″ E, 610 m; 18.xi.2015; in pit galls on leaves of *Ficus vallis-choudae*; D.C. Aléné, #PF3', #PF4; dry mounted and stored in 70% ethanol.











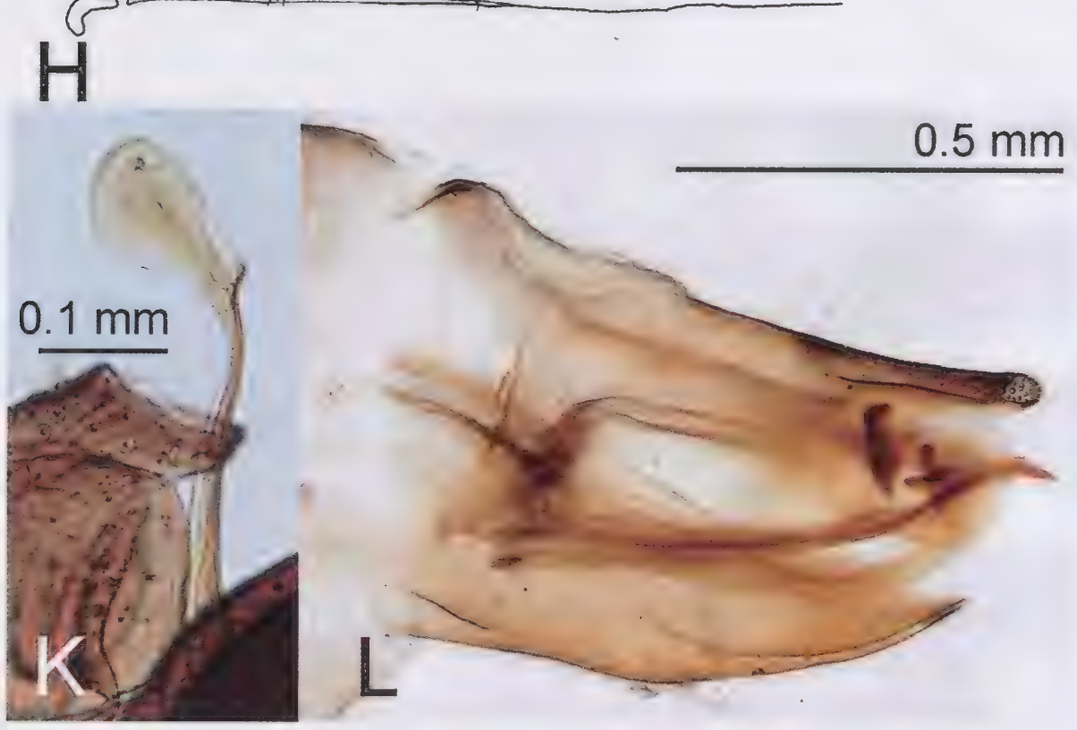


Fig. 3. *Homotoma chlamydodora*. (A) Male and female mating on a leaf of their host plant. (B) Head dorsal view. (C) Antenna. (D) Flagellomeres 7 and 8. (E) Apex of metatibia and metatarsus. (F) Hind leg. (G) Forewing. (H) Costal vein of hindwing. (I) Male terminalia, in profile. (J) Paramere, inner surface. (K) Distal segment of aedeagus. (L) Female terminalia, in profile. (M) Female valvulae.

Description of fifth instar immature (Fig. 4)
Coloration: Yellow to light brown.
Structure: Body, in dorsal view, sub-circular, 1.1 times as long as wide, flat and sclerotized dorsally, convex and membranous ventrally; ventral membrane covered in tubercular sculpture particularly along margins; surrounded by a fringe of evenly, closely spaced truncate sectasetae (Fig. 4A, B). Cephalothorax entire, 1.6 times longer than the abdomen along midline, beset with sparse short simple setae or sectasetae on the disc and denser subacute sectasetae submarginally. Postocular sectaseta absent. Antenna short (0.1-0.2 mm), reaching slightly beyond anterior head margin, tapering apically, eight-segmented with a single apical rhinarium on each of segments 3, 4, 6 and 7; the last segment bearing two terminal setae of unequal length. Forewing pad with a humeral lobe well developed, extending forward to anterior margin of eye. Caudal plate 0.5 times as long as wide, bearing some scattered simple short setae and sectasetae dorsally and groups of denser sectasetae submarginally. Anus ventral, distant from posterior abdominal margin; outer circumanal ring transverse, consisting of one row of pores (Fig. 4C).

Description adult (Figs 5, 6)
Coloration: Head, thorax dorsally and abdomen anteriorly dark-brown to black (Fig. 5A). Compound eyes purple. Younger specimens yellow to light-brown (Fig. 5B).
Structure: Described by Hollis (1984: 30, fig. 79). Body length (including folded wings) of male 1.8-2.4 mm, of female 2.0-2.8 mm. Head width in male 0.5-0.6 mm, in female 0.6-0.7 mm; in profile, strongly inclined at almost 90° from longitudinal body axis; from above as wide as mesoscutum; compound eyes laterally; median ocellus on subcircular frons, lateral ocelli on raised tubercles near hind margin of vertex; genae rounded, weakly prominent ventrally; vertex almost pentagonal, 0.2 mm long, without medial suture, with short setae (Fig. 6A). Antennal sockets largely circular above genae. Antenna (Fig. 6B) 0.8-1.0 mm long, ten-segmented; flagellum slender with weakly widened segments 6-8; first flagellomere more than half as long as flagellomeres 2-8 together; flagellomeres 2, 4, 6, and 7 bearing each a subapical rhinarium; flagellomere 7 with a short, strong subapical seta; terminal setae on flagellomere 8 strongly unequal, one pointed, more than twice as long as flagellomere 8 and one shorter and truncate apically (Fig. 6C). Thorax strongly arched dorsally. Mesothorax larger than pro and metathorax. Forewing (Fig. 6D) about twice as long as wide (length 2.3-2.7 mm in male, 2.4-3.1 mm in female) oval, widest in the middle, broadly, irregularly rounded apically; vein R+M+Cu branching into R and short M+Cu, M 1.8 times longer than R+M+Cu and 5.6 times longer than its branches M_{1+2} and M_{3+4}, Cu 1.5 times longer than Cu_{1a} and 3.0 times longer than Cu_{1b} branch; radular spinules present in the middle of cells m_1, m_2 and cu_1 along wing margin. Hindwing (Fig. 6E)

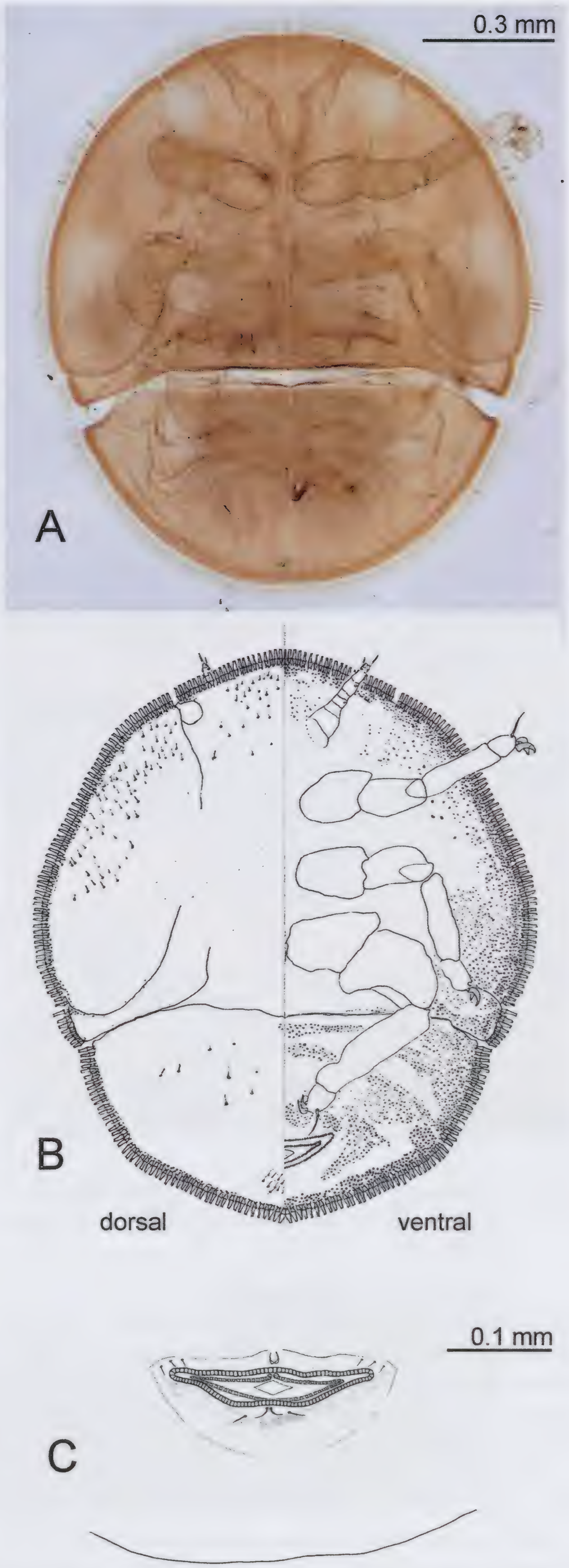


Fig. 4. *Pauropsylla tatrichea*, fifth instar immature. (A) Habitus, cleared specimen, in dorsal view. (B) Habitus with detail of setae and surface sculpture. (C) Anus and transverse circumanal ring.

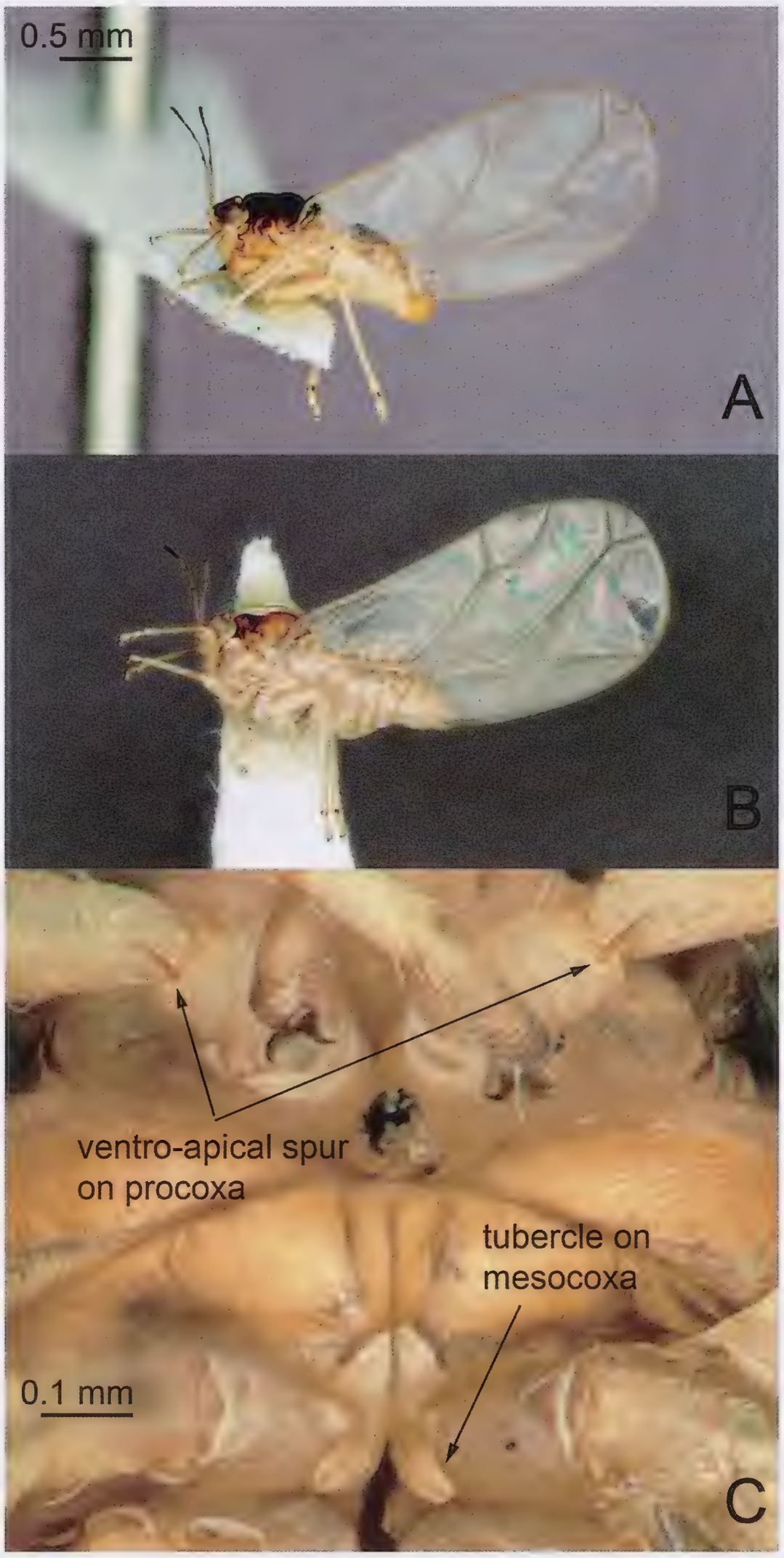


Fig. 5. *Pauropsylla tatrichea*, adult. (A) Male, habitus, in profile. (B) Female, habitus, in profile: (C) Thorax, ventral view.

two thirds as long as forewing with indistinct venation; costal vein (Fig. 6F) with three simple setae proximal of costal break, the setae distal to costal break grouped in a basal group with one seta and a median group with three setae in addition to hamulus. Mesocoxa with an inward-pointing tubercle and a long seta on its outer base (Figs 5C, 6G). Hind leg (Fig. 6H) slender; metacoxa bearing small pointed meracanthus; metafemur bearing three longitudinally arranged ventral sensilla in the middle and long bristles apically; inner apical edge angular (Fig. 6I); metatibia bearing a group of small genual spines (Fig. 6I) and 1+2 or 1+3 apical spurs (Fig. 6J); metabasitarsus lacking spurs (Fig. 6J). Abdomen with setae on tergites 2 and 3 on male and on tergites 3 and 4 on female. Male terminalia (Fig. 6L) with unsegmented proctiger which is, in profile, broadly rounded posteriorly; inner side of posterior lobes bearing two symmetrical areas of 15 peg-like setae (Fig. 6K). Paramere, in profile, lamellar, slightly S-shaped, truncate apically with sclerotized ridge and backward directed small tooth (Fig. 6M). Proximal segment of aedeagus narrowly curved, basally almost twice as long as distal segment which is weakly swollen basally and strongly inflated apically; sclerotized end-tube of ductus ejaculatorius moderately long, sinuate (Fig. 6N). Female terminalia short, cuneate (Fig. 6O); proctiger covered in moderately long setae on caudal two thirds; circumanal ring suboval consisting of two rows of pores (Fig. 6P); subgenital plate triangular, in profile, without ventral transverse groove, subacute apically. Dorsal and ventral valvulae as in Fig. 6Q.

BIOLOGY

Among the 12 *Ficus* species examined at the two sites (Table 1), *Homotoma chlamydodora* and *Pauropsylla tatrichea* were found exclusively on *Ficus vallis-choudae* (Fig. 7A, B); they appear, therefore, locally monophagous on *F. vallis-choudae*. Immatures of *H. chlamydodora* are covered in white flaky wax and infest the terminal buds (Fig. 7C) sitting under the stipules (Fig. 7D) where they pass the whole development until adult emergence. Often, the attacked buds die back (Fig. 7E). Immatures of *P. tatrichea*, on the other hand, colonise the underside of young leaves inducing pit-galls which are covered in abundant white wax strands (Fig. 7F, G). Adults of both species were observed feeding, mating and laying eggs on the same plant.

Homotoma chlamydodora was encountered only at Koutaba (Western Highland) whilst *Pauropsylla tatrichea* was present both at Bafia (Southern Plateau) and Koutaba. Adults and immatures of both psyllid species were present during the entire year (from October 2015 to October 2016) with the highest infestation rates noted in April, corresponding to the early rainy season. This suggests a polyvoltine life cycle with overlapping generations.

DISCUSSION AND CONCLUSIONS

The previously unknown last instar of *Homotoma chlamydodora* resembles that of *H. eastopi* Hollis & Broomfield, 1989 in the general body shape, the three-segmented antennae, a generic feature, and the multi-layered circumanal ring (Aléné *et al.*, 2014), but is less hairy, particularly on the antennae, has a more slender antennal segment 3 and narrower forewing pads which completely lack a humeral lobe (rather than bearing a weakly produced lobe) and differs in the marginal

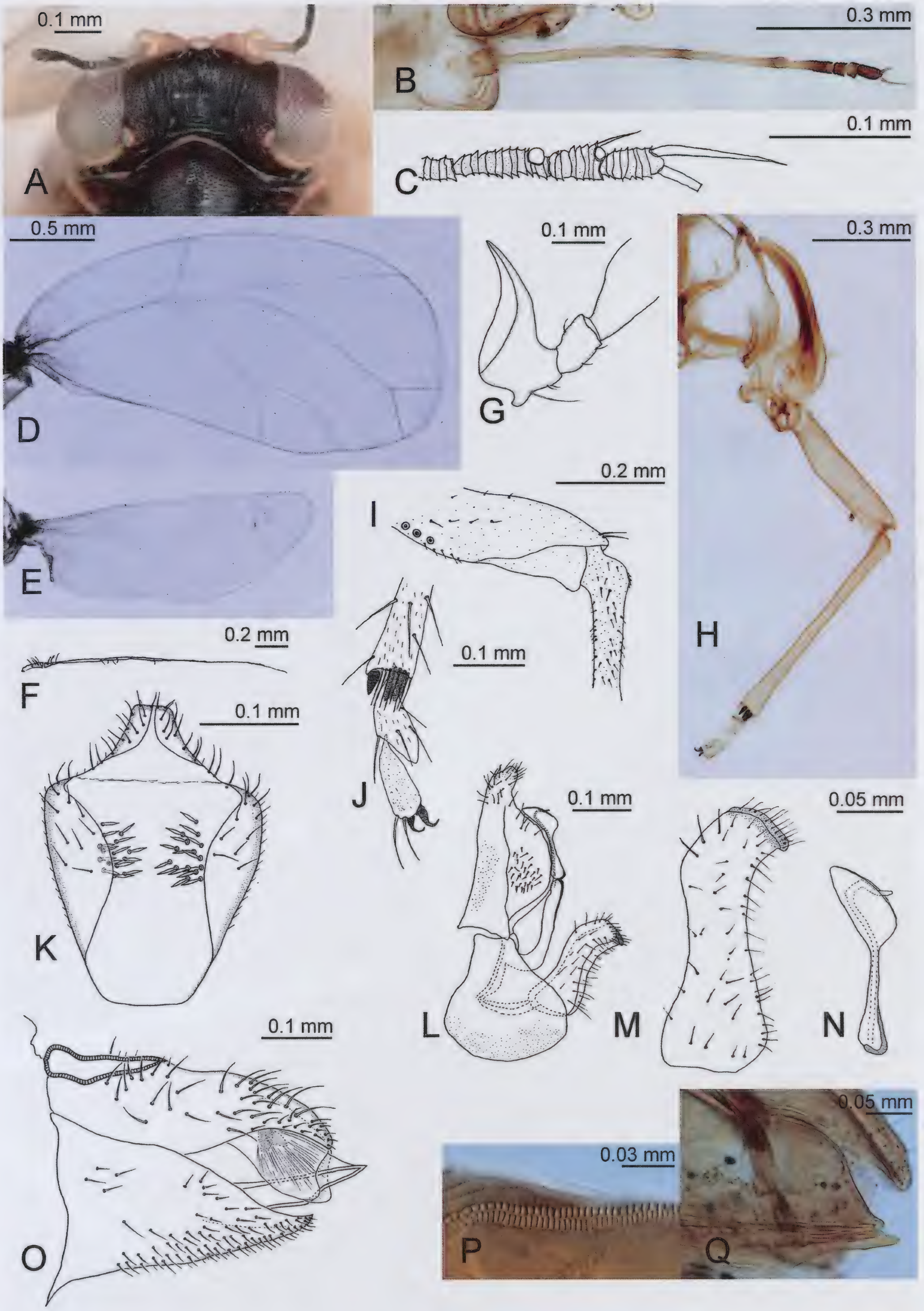


Fig. 6. *Pauropsylla tatrichea*, adult. (A) Head, dorsal view. (B) Antenna. (C) Antennal flagellar segments 6-8. (D) Forewing. (E) Hindwing. (F) Costal vein of hind wing. (G) Mesocoxa showing inward pointing tubercle. (H) Hind leg. (I) Apex of metafemur and basis of metatibia showing sensilla and genual spines. (J) Apex of metatibia with apical spurs and metatarsus. (K) Male proctiger, in rear view (inner face). (L) Male terminalia, in profile. (M) Paramere, inner face. (N) Distal segment of aedeagus. (O) Female terminalia, in profile. (P) Circumanal ring, detail. (Q) Female valvulae.

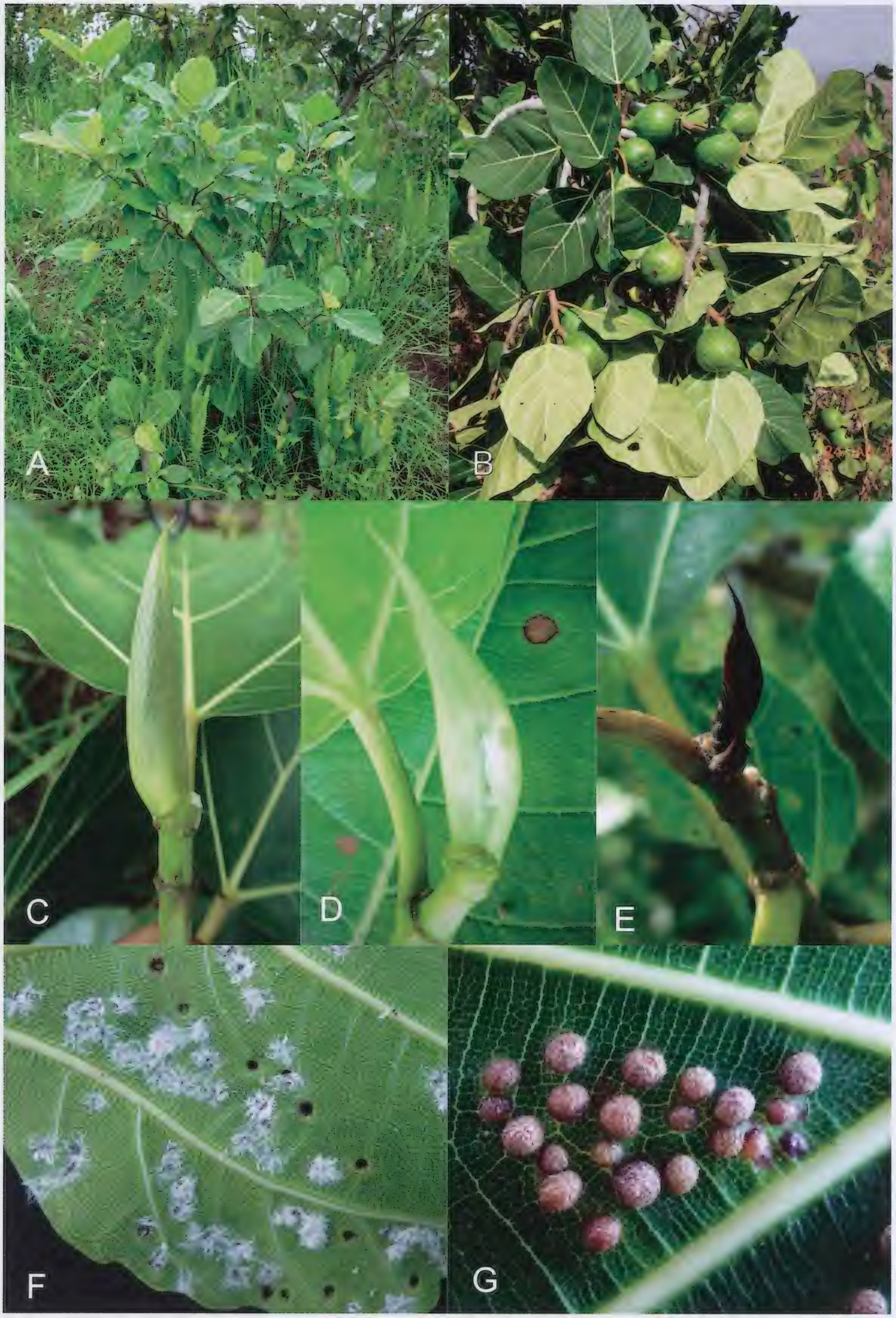


Fig. 7. *Ficus vallis-choudae*. (A) Young plant. (B) Branch with fruits. (C) Healthy bud. (D) Bud infested by an immature of *Homotoma chlamydodora*. (E) Bud withering after being infested by *H. chlamydodora*. (F) Lower surface of a leaf showing pit galls of *Pauropsylla tatrichea* immatures covered with wax. (G) Upper surface of a leaf showing the same galls.

setae of the forewing pad which usually consist of simple setae anteriorly and sectasetae posteriorly (rather than sectasetae throughout). From *Homotoma ficus* (Linnaeus, 1758) it differs in the absence of humeral lobes (rather than large humeral lobes) and the multi-layered circumanal ring (rather than single-layered) (Jerinić-Prodanović, 2011). Adults of *H. chlamydodora* differ from other Afrotropical and Palaearctic *Homotoma* species in the antennal flagellum which is not compressed laterally, and the metabasitarsus which has only one spur. From the closely related *H. eastopi* they differ also in the anteriorly less incised vertex and in details of the venation and pattern of the forewing. *Homotoma chlamydodora* resembles *H. ficus* in the head shape but differs in the narrower forewings and details of the venation.

Hollis (1984) defined three species groups and several ungrouped species within *Pauropsylla*. He assigned *P. tatrichea* to the *P. willcocksi*-group, along with *P. trichaeta* Pettey, 1924, *P. willcocksi* Dçbski, 1918 and two poorly described species from Israel based on the presence of a strong ventro-apical spur on the procoxa (Fig. 5C). The last instar immature of *P. tatrichea* is similar to that of *P. trichaeta* in the almost circular body outline and the dense marginal sectasetae but differs in the presence of dorsal sectasetae, the longer marginal sectasetae and the eight-segmented antenna (rather than 7). The last instar immature of *Pauropsylla tatrichea* differs from *P. willcocksi* in the almost circular body outline, the eight-segmented antenna (rather than 6), the anteriorly strongly produced humeral lobe and the densely spaced marginal sectasetae which are all of the same size (rather than sparsely spaced and of different sizes). *Pauropsylla tatrichea* differs from both *P. trichaeta* and *P. willcocksi* in the absence of a postocular sectaseta. Adults of *P. tatrichea* resemble those of *P. trichaeta* and *P. willcocksi* but are larger, with the clypeus bearing a pair of setae (rather than several setae), with the costa of the hindwing bearing 3-4 (rather than 1-2) setae proximal to costal break and lacking a ventral transverse grove on the female subgenital plate. The males of *P. tatrichea* differ from those of the other species of the *P. willcocksi*-group in the distinctly longer proctiger with two groups of 15 peg-like setae on the inner surface of the posterior expansions (rather than with 25-30 in *P. trichaeta* and up to 22 in *P. willcocksi*), the lamellar, S-shaped, apically truncate paramere (rather than curved backwards and apically blunt) and the apically more inflated distal portion of the aedeagus. An interesting feature is the inward pointing tubercle on the mesocoxa (Figs 5C, 6G). This character is present also in other *Pauropsylla* species and may constitute an autapomorphy of the genus.

In *H. chlamydodora*, the entire immature development takes place under stipules. This is in contrast to the development of *H. eastopi* and *H. ficus*. In *H. eastopi*, the infestation starts on the apical buds from where the immatures progressively spread onto young leaves and twigs (Aléné *et al.*, 2014). The development of immatures of *H. ficus* is similar. In late summer or autumn the eggs are laid in the buds were these overwinter. In spring, the first and sometimes the second instars sit under the stipules. The second and third instars move onto leaf pedicels, leaf blades or fruits where the development continues. In summer the last instars are mostly on the underside of the leaves but also on other structures (Jerinić-Prodanović, 2011; D. Burckhardt, unpublished data). *Homotoma chlamydodora* and *H. eastopi* are polyvoltine and their hosts are evergreen, in contrast to *H. ficus* which is univoltine and its host is deciduous.

Gall inducing psyllids tend to be monophagous while free living species are often narrowly or widely oligophagous (Burckhardt, 2005). *Homotoma chlamydodora* and *Pauropsylla tatrichea* seem to fit this general pattern though the available data are not conclusive. Whereas for *P. tatrichea* we have confirmed data from two localities in Cameroon, for *H. chlamydodora* there are confirmed host records from only one locality in Cameroon, in addition to records of *Ficus natalensis*, *F. petersii* and *F. thonningii* from Angola and South Africa on which adults were collected (Hollis & Broomfield, 1989). Whether these constitute host or casual plants (Burckhardt *et al.*, 2014) should be further investigated. Although this species was found locally on only one host, being considered monophagous, it is possible that, while looking at the entire distributional range, the species could be oligophagous.

It is interesting to note that while *Pauropsylla tatrichea* could be found both at Bafia (Southern Plateau) and Koutaba (Western Highland), *Homotoma chlamydodora* was encountered only at the latter locality. More research will be necessary to determine the factors influencing its distribution.

It is well documented that particular plant species can host several psyllid species such as some species of *Salix* (Salicaceae) (colonised by species of *Bactericera* Puton, 1876 and *Cacopsylla* Ossiannilsson, 1970) (Ossiannilsson, 1992), *Schinus* (Anacardiaceae) (*Calophya* Löw, 1879 and *Tainarys* Brèthes, 1920) (Burckhardt & Basset, 2000), *Eucalyptus* (Myrtaceae) (Spondyliaspidinae and Triozidae) (Hollis, 2004) or *Copaifera* and *Hymenaea* (Fabaceae) (*Apsyllopsis* Burckhardt & Queiroz, 2020; *Colophorina* Capener, 1973; *Jataiba* Burckhardt & Queiroz, 2020; *Mitrapsylla* Crawford, 1914; *Platycorypha* Tuthill, 1945) (Burckhardt & Queiroz, 2020). Sympatric occurrence of closely related psyllids is recorded from *Diclidophlebia eastopi* Vondráček, 1964 and *D. harrisoni* Osisanya, 1969 developing on the leaves of *Triplochiton scleroxilon* (Malvaceae) (Osisanya, 1974), or from *Pseudophacopteron eastopi* Malenovský, Burckhardt & Tamesse, 2007, *P. serrifer* Malenovský & Burckhardt, 2009 and *P. tamessei* Malenovský & Burckhardt, 2009 inducing galls on the leaves of *Dacryodes edulis* (Burseraceae) (Malenovský & Burckhardt, 2009; Nsangou & Tamesse, 2014). There are also examples of plant species which are colonised

by not closely related psyllid species, e.g. *Copaifera langsdorffii* which can host sympatrically up to six psyllid species of three genera, some free living, some gall inducing (Burckhardt & Queiroz, 2020). Percy (2003) suggested that for several psyllid species to share the same host, resources should be partitioned by ecological specialisation, such as free living versus gall inhabiting, or different phenology. We find this pattern in the present study: *H. chlamydodora* and *P. tatrichea* develop on the same tree but occupy different ecological niches, i.e. their immatures are free living and in pit galls, respectively.

Ficus vallis-choudae is a wild fruit tree, fruits of which are consumed by the people of the savannah zones in Cameroon. If this plant should be cultivated in the framework of projects of domestication of some NWFPs in Cameroon (Tsobeng *et al.*, 2016), *Homotoma chlamydodora* and *Pauropsylla tatrichea* are potential pests, especially on saplings. Thus, more studies on the biology of the two psyllid species should be undertaken to guarantee a successful cultivation of this fruit tree.

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REFERENCES

Aléné D.C., Djiéto-Lordon C., Burckhardt D. 2014. The immatures and host plant range of the *Ficus*-feeding jumping plant-louse *Homotoma eastopi* (Hemiptera: Psylloidea) in southern Cameroon. *African Entomology* 22(4): 880-887.

Arnold M. 2002. Clarifying the links between forests and poverty reduction. *International Forestry Review* 4(3): 231-233.

Brèthes J. 1920. Las agallas del Molle de Incienso. *Aspiraciones* 2: 124-134.

Brown R.G., Hodkinson I.D. 1988. Taxonomy and ecology of the jumping plant-lice of Panama (Homoptera: Psylloidea). *Entomonograph* 9: 1-304.

Burckhardt D. 2005. Biology, ecology, and evolution of gall-inducing psyllids (Hemiptera: Psylloidea). *In*: Raman A., Schaefer C.W., Withers T.M. (eds). Biology, ecology, and evolution of gall-inducing arthropods. *Science Publishers, Inc., Enfield, NH*. pp. 143-157.

Burckhardt D., Basset Y. 2000. The jumping plant-lice (Hemiptera, Psylloidea) associated with *Schinus* (Anacardiaceae): systematics, biogeography and host plant relationships. *Journal of Natural History* 34: 57-155.

Burckhardt D., Queiroz D.L. 2020. Neotropical jumping plant-lice (Hemiptera, Psylloidea) associated with plants of the tribe Detarieae (Leguminosae, Detarioideae). *Zootaxa* 4733(1): 1-73.

Burckhardt D., Ouvrard D., Queiroz D., Percy D. 2014. Psyllid host-plants (Hemiptera: Psylloidea): resolving a semantic problem. *Florida Entomologist* 97(1): 242-246.

Burckhardt D., Cho G., Lee S. 2018. *Moriphila furva* gen. and sp. nov. (Hemiptera: Psylloidea: Homotomidae), a new jumping plant-louse from Korea associated with *Morus australis* (Moraceae). *Zootaxa* 4444(3): 299-315.

Capener A.L. 1973. Southern African Psyllidae (Homoptera) – 3: A new genus and new species of South African Psyllidae. *Journal of the Entomological Society of South Africa* 36(1): 37-61.

Crawford D.L. 1914. A monograph of the jumping plant-lice or Psyllidae of the New World. *Smithsonian Institution, United States National Museum, Bulletin* 85: 186 pp.

Dçbski B. 1918. Liste des cécidies signalées en Egypte jusqu'à ce jour. *Mémoires de la Société entomologique d'Egypte* 1(4): 3-38.

Gautier D. 1996. *Ficus* (Moraceae) as part of Agrarian systems in the Bamileke region (Cameroon). *Economic Botany* 50(3): 318-326.

Guérin-Méneville F.-E. 1844. Iconographie du règne animal de G. Cuvier. Insectes. *Baillière, Paris*, 576 pp.

Hollis D. 1984. Afrotropical jumping plant lice of the family Triozidae (Homoptera: Psylloidea). *Bulletin of the British Museum (Natural History), Entomology Series* 49: 1-102.

Hollis D. 2004. Australian Psylloidea. Jumping plant lice and lerp insects. *Australian Government, Australian Biological Resource Study, Canberra, Australia*, 216 pp.

Hollis D., Broomfield P.S. 1989. *Ficus*-feeding psyllids (Homoptera), with special reference to the Homotomidae. *Bulletin of British Museum (Natural History), Entomology Series* 58(2): 131-183.

Jerinić-Prodanović D. 2011. The first finding of the fig psylla *Homotoma ficus* L. (Hemiptera, Psylloidea, Homotomidae) in Serbia. *Pesticidi i fitomedicina* 26(3): 205-212.

Löw F. 1879. Zur Systematik der Psylloden. *Verhandlungen der zoologisch-botanischen Gesellschaft in Wien* 28: 586-610.

Linnaeus C. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species cum characteribus, differentiis, synonymis, locis. Edition decima, reformata. *Laurentii Salvii, Holmiae,* ii + 824 pp.

Pettey F.W. 1924. South African psyllids. *Memoirs of the Entomological Society of Southern Africa* 2: 21-30.

Puton A. 1876. Notes pour servir à l'étude des Hémiptères. Description d'espèces nouvelles ou peu connues. *Annales de la Société entomologique de France* 6: 275-290.

Malenovský I., Burckhardt D. 2009. A review of the Afrotropical jumping plant-lice of the Phacopteronidae (Hemiptera: Psylloidea). *Zootaxa* 2086: 1-74.

Malenovský I., Burckhardt D. & Tamesse J.L. 2007. Jumping plant-lice of the family Phacopteronidae (Hemiptera: Psylloidea) from Cameroon. *Journal of Natural History* 41(29-32): 1875-1927.

Osisanya E.O. 1969. A new species of *Diclidophlebia* (Homoptera: Psyllidae) from Nigeria. *Journal of Natural History* 3: 71-77.

Nsangou I.M., Tamesse J.L. 2014. Populations dynamic of *Pseudophacopteron* spp. (Hemiptera: Phacopteronidae), psyllids pest of *Dacryodes edulis* (Burseraceae) in Cameroon. *International Journal of Agronomy and Agricultural Research* 5(1): 56-73.

Osisanya E.O. 1974. Aspects of the biology of *Diclidophlebia eastopi* Vondracek and *D. harrisoni* Osisanya (Homoptera, Psyllidae). *Bulletin of Entomological Research* 64: 9-17.

Ossiannilsson F. 1970. Contributions to the knowledge of Swedish psyllids (Hemiptera: Psyllidae). *Entomologica Scandinavica* 1: 135-144.

Ossiannilsson F. 1992. The Psylloidea (Homoptera) of Fennoscandia and Denmark. *Fauna Entomologica Scandinavica* 29: 1-346.

Percy D.M. 2003. Radiation, diversity, and host-plant interactions among island and continental legume-feeding psyllids. *Evolution* 57(11): 2540-2556.

Rowland D., Ickowitz A., Powell B., Nasi R., Sunderland T.C.H. 2016. Forest foods and healthy diets: quantifying the contributions. *Environmental Conservation* 44(2): 102-114.

Rübsaamen E.H. 1899. Mitteilungen über neue und bekannte Gallen aus Europa, Asien, Afrika und Amerika. *Entomologische Nachrichte*n 25: 225-282.

Sorrenti S. 2017. Non-wood forest products in international statistical systems. *Non-wood Forest Products Series* no. 22. Rome, FAO.

Tsobeng A., Tchoundjeu Z., Degrande A., Asaah E., Takoutsing B., Sado T. 2016. Contribution de la domestication participative à la culture des PFNL: le cas des groupements paysans des zones de forêts et savanes humides au Cameroun. *In:* FAO, *Vivre et se nourrir de la forêt en Afrique centrale,* Rome, Italy, chapter 15, pp. 147-157.

Tuthill L.D. 1945. Further observations on the Psyllidae of Cuba (Homoptera). *Entomological News* 56: 235-238.

van Noort S., Rasplus J.Y. 2020. Fig web: figs and fig wasps of the world. URL: www.figweb.org (accessed on 15 March 2020).

Vondráček K. 1964. *Diclidophlebia eastopi* sp. n., a remarkable Psyllid from West Africa. *Annals and Magazine of Natural History* 13(6): 289-295.

Vivien J., Faure J.J. 1996. Fruitiers sauvages d'Afrique (Espèces du Cameroun). *Ministère Français de la Coopération, Centre Technique de Coopération Agricole et Rurale (CTA). Nguila-Kerou, Clohars Carnoet France.*

WFO 2020. World Flora Online. Published on the Internet; http://www.worldfloraonline.org (accessed on 20 March 2020).

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Cave-adapted campodeids (Hexapoda, Diplura, Campodeidae) from the Dinarides and adjacent karst regions

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Abstract: Five new species are described, *Plusiocampa (Didymocampa) cvijici* Sendra & Antić, sp. nov., *Plusiocampa (Plusiocampa) atom* Sendra & Antić, sp. nov., *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov., *Plusiocampa (Stygiocampa) dulcici* Sendra & Rađa, sp. nov. and *Plusiocampa (Venetocampa) pirnati* Sendra & Borko, sp. nov. This brings the number of cave-adapted species of campodeids known from the Dinarides, Eastern Alps, Balkan System and Rodope Massif to 28 (one species in the genus *Campodea* and 27 in *Plusiocampa*). Among *Plusiocampa*, four out of five subgenera are present (*Pentachaetocampa* is not present in the region studied): *Didymocampa* (one species), *Plusiocampa* s. str. (15 species), *Stygiocampa* (eight species) and *Venetocampa* (three species), whereby *Stygiocampa* and *Venetocampa* are endemic to the studied region. These results reveal the importance of the Dinarides karst region as a centre of diversification for campodeids and for cave animals in general. A monophyletic subgroup, consisting of *Stygiocampa*, *Venetocampa* and *Plusiocampa* s. str. and characterized by the absence of medial posterior thoracic macrosetae, presumably colonized the Dinaric plate during the middle of the Cenozoic and occurs in that area since then.

Keywords: *Plusiocampa* - *Stygiocampa* - *Venetocampa* - *Didymocampa* - Plusiocampinae - taxonomy - biogeography - colonization.

INTRODUCTION

The order Diplura encompasses ten families with 1009 species, of which the Campodeidae and the Japygidae are the most diversified, comprising 85% of the total diversity (Koch, 2009; Sendra *et al.*, 2021). Diplurans live in cryptic hypogean habitats all over the world, except for the polar circles and regions with permafrost soils (Condé, 1956; Sendra *et al.*, 2021). They have successfully colonized cave ecosystems, particularly so the family Campodeidae, which encompasses 144 cave-adapted species that represent 30% of the total family diversity (Sendra *et al.*, 2020a, b). Seventy percent of cave-adapted Campodeidae are distributed in European and Mediterranean karst regions (Sendra *et al.*, 2020a). Prior to our study, 22 obligate cave-dwelling campodeid species were known from the Dinarides and adjacent karst regions, from the Eastern Alps to the Balkan System, and the Rhodope Massif (Sendra *et al.*, 2020a). The number of cave-restricted species of different taxa is exceptionally high in the Dinarides and this region has been recognized as one of the world's major hotspot of subterranean biodiversity (Culver *et al.,* 2006; Sket *et al.,* 2004; Sket, 2012; Zagmajster *et al.,* 2014; Antić & Makarov, 2019). Two campodeid genera inhabit

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the studied region: *Campodea* Westwood, 1842 and *Plusiocampa* Silvestri, 1912, with one endemic subgenus *Stygiocampa* Silvestri, 1934 (Bareth & Condé, 2001; Condé & Bareth, 1996; Sendra *et al.,* 2020a).

The study of cave-adapted campodeids in the Dinaric and adjacent karst regions has a long history, starting with Joseph (1882) who described the troglomorphic species *Campodea nivea* Joseph, 1882 from the Jama v Košanskih Grižah Cave near Pivka (Slovenia). The species description encompasses only a short diagnosis, as it is the case with many other species described during this period (Sendra *et al.,* 2020b). Denis (1923) and later Silvestri (1934, 1947) redescribed *C. nivea* in detail and proposed a new combination (Silvetri, 1934): *Plusiocampa (Stygiocampa) nivea* (Joseph, 1882). Further research revealed 11 new cave-adapted *Plusiocampa* species throughout the western Balkans: four in the subgenus *Stygiocampa* and seven in the subgenus *Plusiocampa* (Condé, 1947, 1948, 1950, 1959; Silvestri, 1931; 1933a, b). Ten new descriptions of cave-adapted campodeids followed at the end of the 20th and the beginning of the 21st century (Bareth, 1988; Bareth & Condé, 1984, 2001; Condé, 1974; Condé & Bareth, 1996; Neuhertz, 1984). Recently, Sendra *et al*. (2020a) revealed more than two hundred records of 22 cave-adapted campodeids species throughout the study area, identifying this region as a possible centre of campodeid diversification in caves, along with other well-sampled and rich regions as the Pyrenees and Cantabria (Sendra *et al.,* 2020a, b). Recently collected diplurans from caves in the Dinarides and adjacent regions point to an overlooked diversity hotspot in that region. In the present paper we describe five new species from 15 caves and give additional biogeographic data on cave-adapted campodeids of the region.

MATERIAL AND METHODS

The specimens stored in ethanol 70-75% were washed using distilled water, mounted on microscope slides in Marc André II solution, and examined under a phase-contrast optical compound microscope (Leica DMLS). The illustrations were made with a drawing tube, while measurements were taken with an ocular micrometer. To measure body length, the specimens were mounted *in toto* and measured from the base of the distal macrochaetae of the frontal process to the supra-anal valve of the abdomen. Several specimens were coated with palladium-gold and used for SEM (Hitachi S-4100) photography and measurement of the sensilla.

The morphological descriptions and abbreviations follow Condé (1956). We use the term "gouge sensilla" for the concave-convexly-shaped sensilla on the antennae, and "gard setae" for the characteristic two short setiform sensilla near the lateral anterior sensillum of each labial palp (Bareth & Condé, 1981). For the position of macrosetae we adopt the abbreviations of Condé (1956): *ma* = medial-anterior, *la* = lateral-anterior, *lp* = lateral-posterior, and *post* = posterior; *sma, sla, slp, spost* for submacrosetae. For head macrosetae we follow Wygodzinsky (1944): *asl* = anterior-sublateral, *psm* = posterior-submedia, and *psl* = posterior-sublateral macrosetae.

The type specimens and other material studied are kept in the following institutions:

IZB	Institute of Zoology, University of Belgrade, Serbia
MHNG	Muséum d'histoire naturelle de Genève, Switzerland
NHMB	Natural History Museum of Barcelona, Spain
Coll. AS	private collection of Alberto Sendra, València, Spain
NHMZOO	Natural History Museum & Zoo, Split, Croatia
PMSL	Slovenian Museum of Natural History, Ljubljana, Slovenia.

TAXONOMY

Family Campodeidae Meinert, 1865
Subfamily Plusiocampinae Paclt, 1957
Genus *Plusiocampa* Silvestri, 1912
Subgenus *Didymocampa* Paclt, 1957

Plusiocampa (Didymocampa) cvijici Sendra & Antić, sp. nov.

Figs 1-6, Table 1

Type material: IZB; male holotype; western Serbia, Hadži-Prodanova pećina Cave, near the village of Raščići, Ivanjica, 650 m asl.; 28th June 2018; leg. D. Antić. – Coll. AS; one male and one juvenile paratypes; collected together with the holotype. – Coll. AS; one female paratype; same cave and collector; 17th October 2018. All specimens mounted in Marc André II solution.

Other material studied: Coll. AS; one specimen of unknown sex collected together with the holotype; mounted on an aluminium stub and coated with palladium-gold.

Etymology: This species is named after Prof. Dr Jovan Cvijić (1865-1927), a widely known Serbian geomorphologist, former president of the Serbian Royal Academy of Sciences, and one of the first explorers of the Hadži-Prodan Cave in 1914. The epithet is a name in the genitive case.

Description:

Body: Body lengths 3.9 mm (female paratype), 3.3 mm (holotype), 3.4 mm (male paratype) and 2.6 mm (juvenile paratype) (Fig. 1). Epicuticle smooth when examined under an optical microscope. Body clothed with few

Fig. 1. Habitus of *Plusiocampa (Didymocampa) cvijici* Sendra & Antić, sp. nov. from Hadži-Prodanova pećina Cave, Raščići, Ivanjica, western Serbia (photograph by Dragan Antić).

medium-sized, thin, smooth (or with one thin distal barb) setae.

Head: Antennae of same length as body in juvenile and slightly shorter in adults (Table 1), with 27 (female paratype), 29 (juvenile paratype), and 30 (male holotype) antennomeres. Bacilliform sensillum of third antennomere in ventral position, between macrosetae *d* and *e,* 20 μm long. Medial antennomeres slightly elongated: 1.5-1.6 times longer than wide; apical antennomere 1.5 longer than wide. Each medial and distal antennomere with 18-20 thin gouge sensilla (30 μm) in a single distal whorl, as well as with two conical sensilla (7 μm) in same whorl. Cupuliform organ occupying 1/3 of total length of last antennomere; with 12-16 spheroidal olfactory chemoreceptors with an eccentric or centric column surrounded by concentric, incompleted expansions covered by a visible polygonal net with porous surface (Figs 2-3). Protruding frontal process carrying numerous tubercular setae. Length ratios of three macrosetae along each side of line of insertion of antennomere and *x* setae being 30/37/30/42, a/i/p/x in holotype. Three pairs of longer macrosetae on dorsal side of head in *asl, psm, psl* position. Labial palps suboval, each with conical latero-external sensillum near two gard setae, seven normal setae in anterior portion, and up to 60-80 neuroglandular setae in medial and posterior position.

Thorax: Pronotum with 1+1 *ma*, 3+3 *la*, 2+2 $lp_{2,3}$ macrosetae; mesonotum with 1+1 *ma*, 3+3 (3+2) la_{1-3}, 2+2 $lp_{2,3}$; metanotum with 1+1 *ma*, 1+1 *la*, 2+2 $lp_{2,3}$; long, thin notal macrosetae with barbs in distal half; few smooth (or with a thin distal barb) clothing setae (holotype: 5+3, 14+13, 15+14 on pronotum, mesonotum, and metanotum) (Fig. 4). Metathoracic legs reaching eighth abdominal segment, with two dorsal femoral macroseta of 0.25-0.20 mm length, with thin barbs in distal three-fourths, as well as two ventral macrosetae similar in shape and length as dorsal macrosetae (Fig. 5); two tibial metathoracic macrosetae with 1-5 thin distal barbs; calcars with long, thin barbs in several rows on one side; tarsus with two ventral rows of larger setae with distal barbs and with two dorsal and two ventral subapical smooth macrosetae; slightly unequal claws (posterior claw 1.2 longer than anterior claw) with large lateral crests; posterior claw with a small backward overhang.

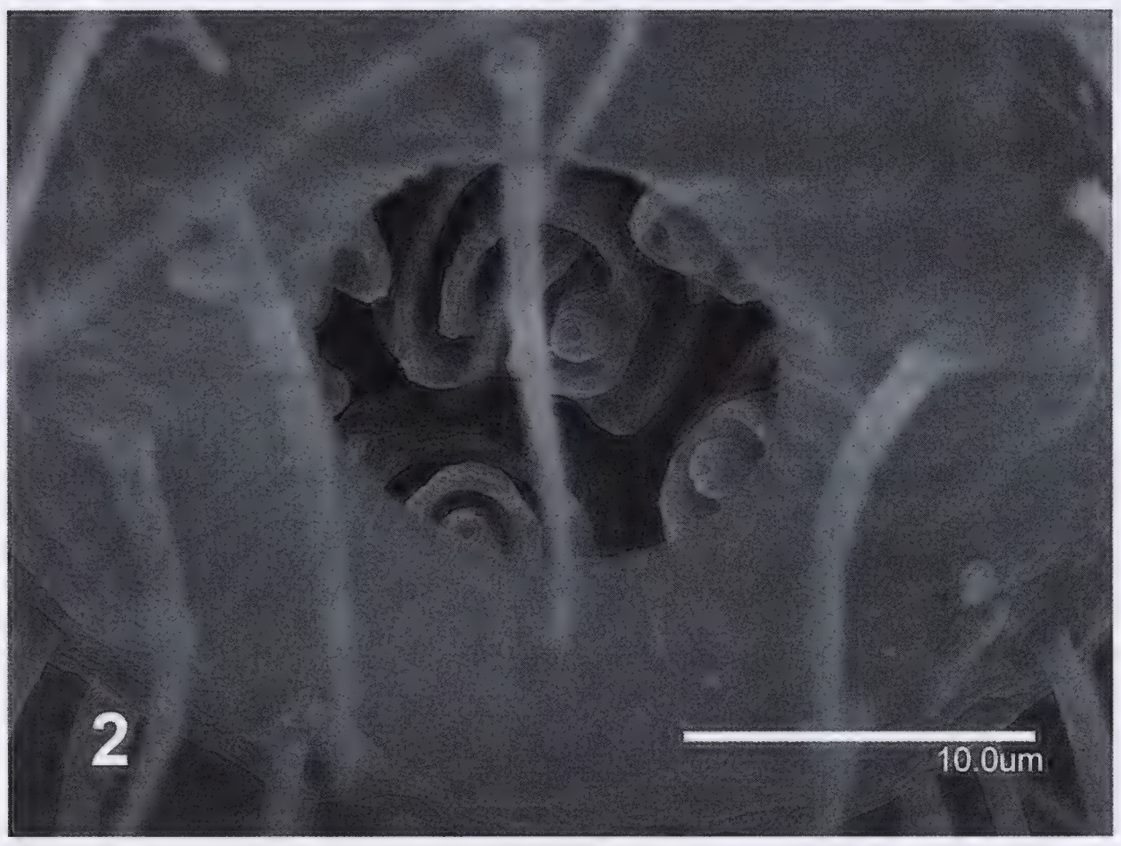
Abdomen: Urotergites I-III with 1+1 $post_1$ macrosetae; urotergite IV with 1+1 *la*, 2+2 $post_{1,2}$ macrosetae; urotergite V with 1+1 *la*, 5+5 $post_{1-5}$; urotergite VI with 2+2 (1+1) *la*, 5+5 $post_{1-5}$; urotergite VII with 2+2 *la*, 5+5 $post_{1-5}$; urotergite VIII with 6+6 *post*; abdominal segment IX with 8+8 (8+7) *post* macrosetae; all urotergal macrosetae long and barbed in distal three-fourths; urosternite I with 7+7 macrosetae, urosternites II-VII with 5+5, and urosternite VIII with 2+2 macrosetae. Stylar setae with a few barbs: apical seta with basal tooth and two thin barbs, subapical seta with two or three thin barbs, and medio-sternal seta with a long distal barb and a thin short one. Complete cercus of holotype 1.3 times longer than body, with base divided into three secondary articles followed by nine primary articles (Table 1); each primary cercus bearing 2-10 irregularly arranged whorls of long barbed macrosetae, 1-2 distal whorls of smooth long setae, and one apical whorl of short thin setae with tiny distal barbs.

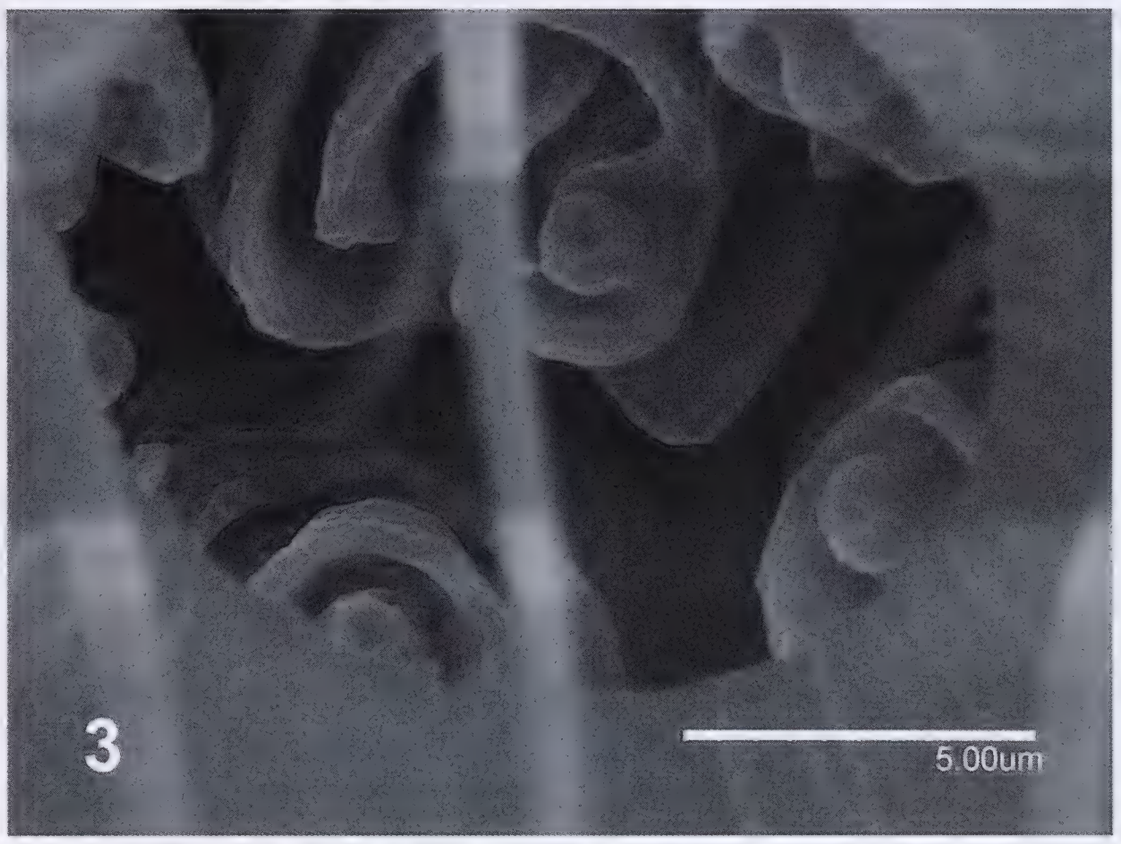
Secondary sex characters: First urosternite of males with two rows of up to 43 glandular g_1 setae, subcylindrical appendages slightly enlarged in distal area, with up to 25 glandular a_1 setae (Fig. 6). Females with subcylindrical appendages carrying up to nine glandular a_1 setae.

Taxonomic affinities: *Plusiocampa (Didymocampa) cvijici* sp. nov. shares some taxonomical features

Table 1. *Plusiocampa (Didymocampa) cvijici* Sendra & Antić, sp. nov. Length (in mm) of body, antennae, femur, tibia and tarsus of metathoracic legs and of cerci, in addition to number of antennomeres and cercal primary articles.

specimen	body	antennae	number of antennomeres	femur	tibia	tarsus	number of primary cercal articles	cercus
Paratype, juvenile	2.6	2.6	29	-	-	-	-	-
Holotype, male	3.3	3.2	30	0.48	0.53	0.44	9	4.3
Paratype, male	3.4	-	-	0.50	0.64	0.45	-	-
Paratype, female	3.9	3.4	34	0.52	0.58	0.45	-	-





Figs 2-3. *Plusiocampa (Didymocampa) cvijici* Sendra & Antić, sp. nov. (2) Cupuliform organ of last antennomere. (3) Detail olfactory receptors of cupulifom organ.

with two species of the presumably paraphyletic subgenus *Didymocampa*: *Plusiocampa (Didymocampa) evallonychia* Silvestri, 1949 from Crimenan caves and *Plusiocampa (Didymocampa) euxina* Condé, 1996 from Movile Cave in Romania. Among other taxonomical features we point out the following: the absence of medial posterior macrosetae on mesonotum and metanotum; 1+1 posterior macrosetae on first to third urotergites; 5+5-6+6 macrosetae on second to seventh urosternites; stylar setae with a few thin barbs (Condé, 1996; Sendra *et al.,* 2020a; Silvestri, 1949). *Plusiocampa (D.) cvijici* sp. nov. differs from both species by some taxonomical features: 3+3 and 1+1 lateral anterior macrosetae on mesonotum and metanotum [*vs.* 2+2 *la*, 1+2 *la* in *P. (D.) euxina* and 1+1 *la*, 0+0 *la* in *P. (D.) evallonychia*], 8+8 post macrosetae on abdominal segment IX [*vs.* 9+9 in *P. (D.) euxina* and *P. (D.) evallonychia*]. *Plusiocampa (D.) euxina* is geographically and taxonomically closest to *P. (D.) cvijici* sp. nov. due to similarities in the macrosetae distribution pattern, their slightly subequal claws, and few smooth notal clothing setae. The new species differs from *P. (D.) euxina* not only in the aforementioned number of lateral anterior notal macrosetae and the number of macrosetae on the eighth abdominal segment, but *P. (D.) euxina* also has few tubercular setae on the frontal process, three ventral tibial macrosetae, short lateral processes with a few barbs on the pretarsus, and barbed subapical tarsal setae. *Plusiocampa (D.) cvijici* sp. nov. is distinguished from *P. (D.) euxina* by more tubercular setae, two ventral tibial macrosetae, longer smooth lateral processes protruding beyond the tips of the claws, and smooth subapical tarsal setae.

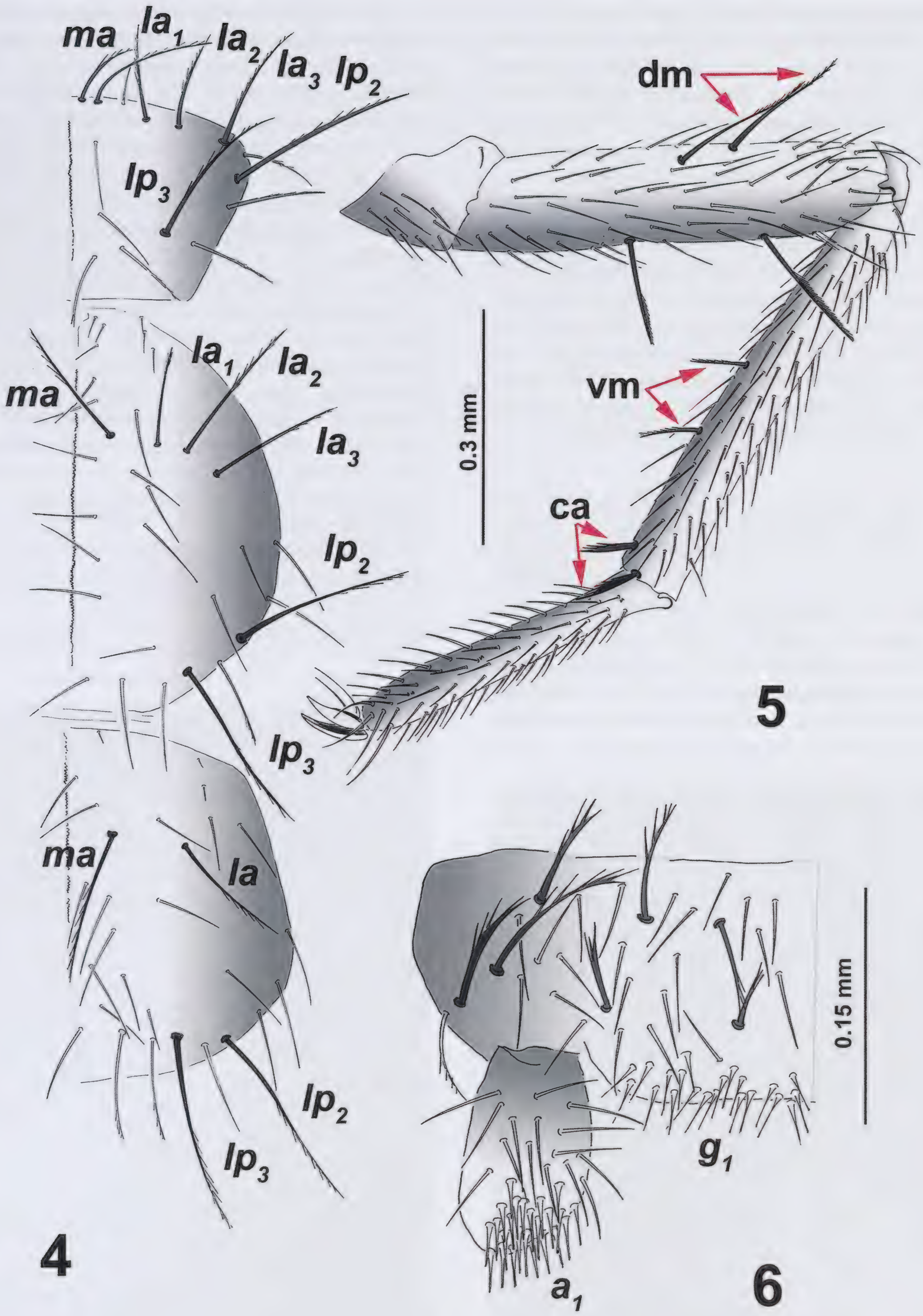
Type locality: The Hadži-Prodanova pećina Cave, located in western Serbia (the Dinarides), is a national natural monument and a well-known Palaeolithic site rich in late Pleistocene mammal fossils (Mihailović & Mihailović, 2003; Bogićević *et al.,* 2017) (Fig. 7). The entrance of this multilevel cave with a length of 420 m is situated at 630 m a.s.l. The cave is mainly dry, without a cave stream, and it consists of three main chambers: the lower, middle and upper one. It is a residence for six Chiroptera species (Paunović, 2016). Besides, the cave is rich in arthropods, of which the most important are Balkan troglophiles, viz., the harvestman *Mitostoma cancellatum* (Roewer, 1917), the millipedes *Apfelbeckia insculpta* (L. Koch, 1867) and *Brachydesmus herzogowinensis* Verhoeff, 1897, as well as Serbian troglobionts such as the springtail *Pseudosinella ivanjicae* Ćurčić, Lučić & Boškova, 1999 and the ground beetle *Duvalius starivlahi* Guéorguiev, Ćurčić & Ćurčić, 2000, both only known from the Hadži-Prodanova pećina Cave. The new species was found under stones in the main (middle) chamber of the cave.

Subgenus *Plusiocampa* s. str. Silvestri, 1912

Plusiocampa (Plusiocampa) atom Sendra & Antić, sp. nov.

Figs 8-10, Table 2

Type material: MHNG; female holotype; Bosnia & Herzegovina, Lukina pećina Cave, Srednja stijena, Tajan, Zavidovići; 11th July 2018; leg. D. Antić. – MHNG; one male a one female paratypes (labelled ♂2 paratype and ♀7 paratype) collected from the same cave on 17th November 2019; leg. A. Bajraktarević, E. Balić, D. Zgonjanin, A. Sinković. – NHMB; two female paratypes (labelled ♀2 paratype and ♀6 paratype) collected together with the holotype. – Coll. AS.; one male, three female and one juvenile paratypes (labelled ♂1 paratype, ♀2, ♀3, ♀7 paratypes and J1 paratype) collected together with the holotype.



Figs 4-6. *Plusiocampa (Didymocampa) cvijici* Sendra & Antić, sp. nov., holotype. (4) Pronotum, mesonotum and metanotum of right side of body (5) Right metathoracic leg; dm = dorsal macrosetae, vm = ventral macrosetae; ca = calcars. (6) First urosternite of right side; a_1 = glandular a_1 setae, g_1 = glandular g_1 setae.

Other material studied: Coll. AS; one female collected together with the holotype. – Coll. AS; three females and one juvenile; same cave and collectors, sampled on 17th November 2019; mounted in Marc André II solution. – Coll. AS; one specimen of unknown sex collected together with the holotype; mounted on an aluminium stub and coated with palladium-gold.

Etymology: This species is named in honor of the members of the "Atom" Sport and Science-Research Club, Zavidovići, Bosnia and Herzegovina, for their determination and hard work at protecting speleological objects in Bosnia and Herzegovina, for collecting cave animals, as well as for saving human lives in the mountains of Bosnia and Herzegovina whilst risking their own lives. Additionally, D.A. is grateful to them for their long-lasting friendship. Noun in apposition.

Description:

Body: Body length 4.4 mm (males), 4.5-6.5 mm (females) and 3.6 mm in one juvenile (Fig. 8) (Table 2). Epicuticle smooth when seen under optical microscope; body with numerous medium-sized, smooth (or with a distal thin barb) clothing seta.

Head: Antennae length 0.73-0.84, shorter than body (Table 2), with 32-38 antennomeres (perhaps regenerated distal antennomers). Bacilliform sensillum of third antennomere in a ventral position, between macrosetae *d* and *e,* 15 μm long. Medial antennomeres slightly elongated, 1.7 times longer than wide; apical antennomere 2.3 times longer than wide. Eight to ten thin gouge sensilla (28 μm) in a single distal whorl on each medial and distal antennomere; two conical sensilla (9 μm) in same whorl. Cupuliform organ occupying less than 1/3 of total length of last antennomere, with 7-9 spheroidal olfactory chemoreceptors with an eccentric or centric column surrounded by a concentric fold. Non-protruding frontal process with three smooths anterior macrosetae and no tubercular setae. In holotype these macrosetae along each side of line of insertion of antennomere and smooth *x* setae with length ratios of *a/i/p/x,* 36/34/29/39, respectively. Three pairs of slightly longer smooth macrosetae on dorsal side of head in *ma, la, lp* position. Labial palps suboval, each with a conical latero-external sensillum near two gard setae, six normal setae in anterior portion, and up to 60 neuroglandular setae in medial and posterior position.

Thorax: Pronotum with 1+1 *ma*, 4+4-3+3 *la*, 2+2 $lp_{2,3}$ macrosetae; mesonotum with 1+1 *ma*, 3+3 la_{1-3}, 2+2 $lp_{2,3}$; and metanotum with 1+1 *ma*, 1+1 *la*, 2+2 $lp_{2,3}$; long barbed notal macrosetae with barbs in distal two-

Fig. 7. Entrance of the Hadži-Prodanova pećina Cave, Raščići, Ivanjica, western Serbia (photograph by Bojan Ilić).

Fig. 8. Habitus of *Plusiocampa (Plusiocampa) atom* Sendra & Antić, sp. nov. (left) from Lukina pećina Cave, Srednja stijena, Tajan, Zavidovići, Bosnia & Herzegovina. On the right is a specimen of *Brachydesmus mulaomerovici* Makarov, Ćurčić & Antić in Antić *et al.*, 2013 (photograph by Dragan Antić).

Table 2. *Plusiocampa (Plusiocampa) atom* Sendra & Antić, sp. nov. Length (in mm) of body, antennae, femur, tibia and tarsus of metathoracic legs, in addition to number of antennomers. Asterisks indicate presence of telescoped body segments.

specimen	body	antennae	number of antennomeres	femur	tibia	tarsus
J1 paratype	3.6	-	-	0.64	0.62	0.60
♂1 paratype	4.4 (*)	-	-	0.77	0.80	0.72
♂2 paratype	4.4	3.7	34	0.56	0.57	0.52
♀1 paratype	4.5 (*)	-	-	0.78	0.79	0.72
♀6 paratype	4.8	4.0	32	0.90	1.00	0.80
♀5 paratype	5.3	-	-	0.93	0.84	0.81
♀ holotype	5.4	4.3	38	0.74	0.78	0.67
♀7 paratype	6.4	4.7	36	0.81	0.89	0.77
♀4 paratype	6.5	-	-	1.05	1.00	0.84

thirds; smooth clothing setae or clothing setae with a thin distal barb, and longer marginal setae with thin distal barbs in their distal half (Fig. 9). Metathoracic legs reaching the ninth abdominal segment, with similar lengths of femur, tibia and tarsus, including pretarsus (Fig. 9) (Table 2). One dorsal femoral macroseta in distal half with thin 0.20-0.30 mm long barbs; three barbed ventral macrosetae slightly shorter than dorsal macrosetae; three short tibial metathoracic macrosetae barbed in distal half; calcars with thin barbs in several rows on one side; tarsus with two ventral rows of slightly larger setae with distal barbs; two smooth dorsal subapical setae and two barbed ventral setae on tarsus; claws slightly unequal (posterior claw 1.2-1.3 times longer than anterior claw), with large lateral crests and smooth setiform lateral processes; posterior claw with large backward overhang (Fig. 10).

Abdomen: Urotergites I-III with 1+1 $post_1$ macrosetae; urotergite IV with 1+1 *la*, 3+3 (4+3) $post_{1-3}$ macrosetae; urotergite V-VII with 1+1 *la*, 5+5 $post_{1-5}$; urotergite VIII with 6+6 *post*; abdominal segment IX with 8+8 *post* macrosetae; all urotergal macrosetae long and barbed in distal three-fourths; urosternite I with 7+7 macrosetae; urosternites II-VII with 5+5; urosternite VIII with 2+2 macrosetae; urosternal macrosetae with a few long distal barbs. Stylus with smooth apical seta carrying a basal tooth, subapical and medio-sternal setae with four or five long thin barbs. No intact cercus in any specimen; the most complete cercus 4.5 mm long (♀6-paratype), with basal article divided into three secondary articles followed by eight primary articles; each primary cercal article bearing 2-8 irregulary shaped whorls of long macrosetae with thin distal barbs, one distal whorl of smooth long setae, and one apical whorl of short thin setae with tiny distal barbs.

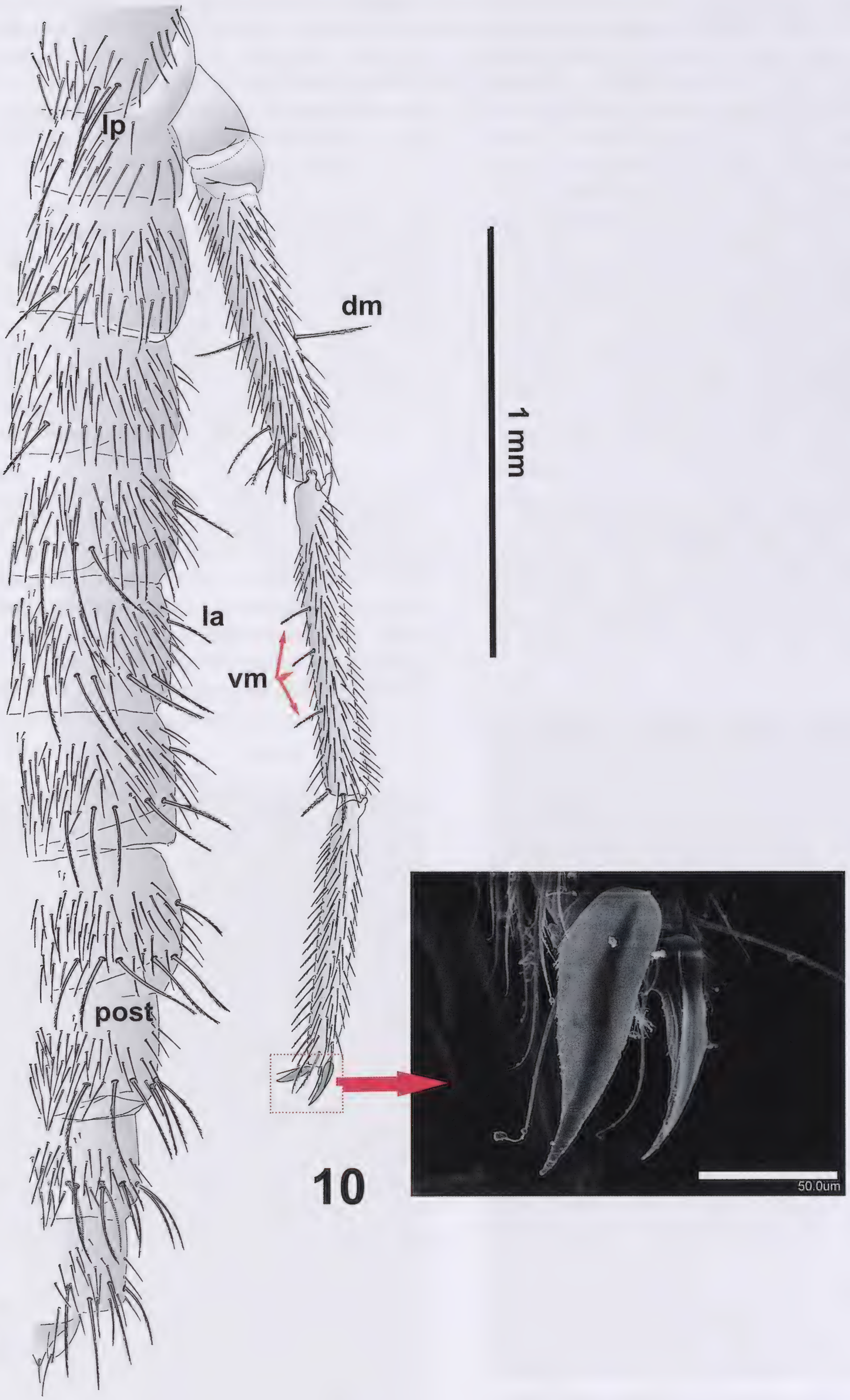
Secondary sex characters: First urosternite of males bearing a narrow field with one or two rows of up to 29 glandular g_1 setae; subcylindrical appendages with a small field of up to 15 glandular a_1 setae; females possessing subcylindrical appendages with up to 13 glandular a_1 setae.

Taxonomic affinities: *Plusiocampa (P.) atom* sp. nov. shows similarities with *P. (P.) latens* Condé, 1948, a species with several known localities in the Dinaric karst (Sendra *et al.,* 2020a). Both species have equal macrosetae patterns on thorax and abdomen (Condé, 1948). *Plusiocampa (P.) atom* sp. nov. differs from *P. (P.) latens* in two characters: it has three ventral macrosetae and up to 38 antennomeres, whereas *P. (P.) latens* has only two ventral macrosetae and 24-27 antennomeres.

Type locality: The Lukina pećina Cave is located in the "Tajan" Nature Monument, in central Bosnia and Herzegovina (Fig. 11). This is a cave system with two entrances close to each other and a total length of 247 m. It is well-known for its remains of an autochthonous Upper Pleistocene fauna and for traces of the cave bear (Lukić-Bilela *et al.,* 2009). As far as arthropods are concerned, two other troglobites were found in the cave, viz., the millipede *Brachydesmus mulaomerovici* Makarov, Ćurčić & Antić in Antić *et al.*, 2013 and the woodlouse *Cyphonethes tajanus* Karaman & Horvatović, 2018, both recently discovered and described, and endemic to subterranean habitats in the "Tajan" Nature Monument.

Plusiocampa (Plusiocampa) aff. *elongata* Ionescu, 1955

Material studied: Coll. AS; three males and five females; Serbia, Pričevska pećina Cave, Pričevac, Papratna, Stara Planina; 17th June 2019; leg. D. Antić & D. Stojanović.



Figs 9-10. *Plusiocampa (Plusiocampa) atom* Sendra & Antić, sp. nov., holotype. (9) Posterior portion of metathorax and abdomen, right side of body; dm = dorsal macrosetae, vm = ventral macrosetae. (10) Pretarsus, dorsal view.

Fig. 11. Entrances of Lukina pećina Cave, Srednja stijena, Tajan, Zavidovići, Bosnia & Herzegovina (photograph by Emir Balić).

Subgenus *Stygiocampa* Silvestri, 1934

Plusiocampa (Stygiocampa) barethae Sendra & Rađa, sp. nov.

Figs 12-41, Table 3

Type material: MHMZOO; male holotype; Croatia, Grabovčića jama Cave, Radošić; 4th November 2014; leg T. Rađa. – MHMZOO; one male and five female paratypes (labelled ♂2 paratype, and ♀5 to ♀9 paratypes); same cave and collector as holotype sampled 27th October 2014. – MHNG; two female paratypes (labelled ♀1 paratype and ♀4 paratype); same cave, data and collecter as holotype. – NHMB; one female paratype (labelled ♀11 paratype); same cave and collector as holotype; sampled 27th October 2014. – Coll. AS; two female paratypes (labelled ♀2 paratype and ♀3 paratype); same cave, data, and collector as holotype. – Coll. AS; one male and three female paratypes (labelled ♀10 paratype, ♀12 paratype, ♀13 paratype and ♂3 paratype); same cave and collector as holotype sampled 27th October 2014.

Other material studied: Coll. AS; two males and two females from the same cave and collector; sampled on 27th October 2014; mounted on an aluminium stage and coated with palladium-gold.

Etymology: This species is dedicated to the French zoologist Camille Bareth, who has been working with diplurans throughout her prolific career and described 27 new species and 3 subspecies of troglobitic campodeids. She also worked intensely on the morphology and physiology of the group, to which she devoted more time and effort than any other researcher. In addition, she is the co-author of an article where she and her colleague Dr Bruno Condé suggested the possibility that the specimens identified by them as *Plusiocampa (Stygiocampa)* cf. *remyi*, could belong to a new taxon. This is confirmed and the new species is described below. The specific epithet is a name in the genitive case.

Description:

Body: Body length 3.4-5.9 mm (males, n= 3), 5.5-8.7 mm (females, n= 11) (Table 3). Epicuticle smooth under

optical microscope, when seen at high magnification, weakly reticulated, showing irregular polygonal structures of various sizes (Fig. 20); body set with numerous moderately long clothing setae with thin barbs almost all over over surface.

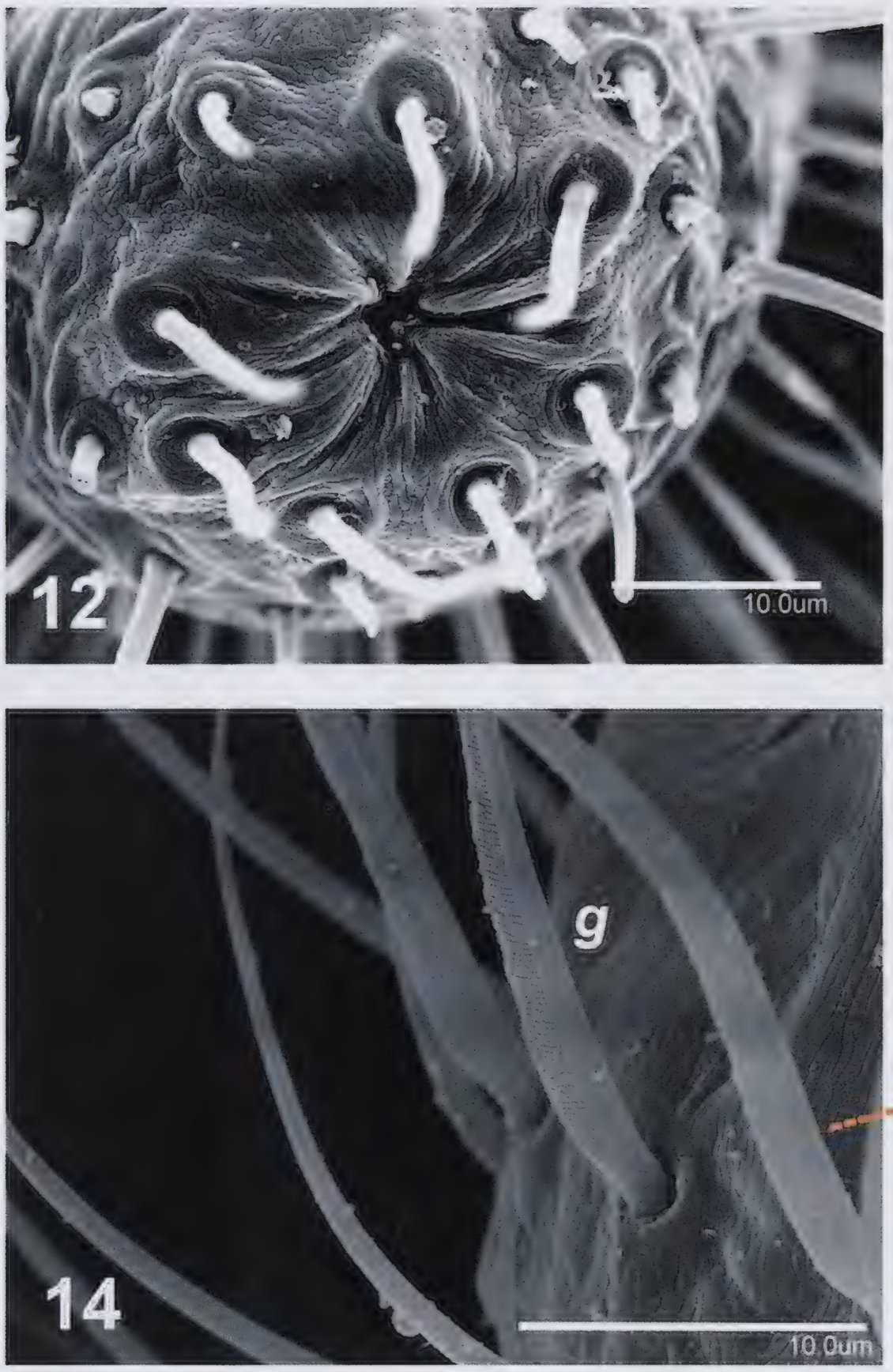
Head: Eleven apparently complete and intact antennae with 40-50 antennomeres; antennae 1.07-1.25 times longer than body (Table 3); medial antennomeres 2-3 times longer than wide; apical antennomere 3 times longer than wide. Cupuliform organ with several uncountable, complex and apparently laminar olfactory chemoreceptors opening to the exterior through a very narrow hole (Fig. 12). Distal and central antennomeres with three whorls of macrosetae carrying distal barbs and scattered smooth setae, as well as a single distal whorl of 16-18 long gouge sensilla (26-38 μm long), and up to two conical 8 μm long sensilla (Figs 13-15). Proximal antennomeres with typical trichobothria, plus a small bacilliform sensillum (8 μm long) on third antennomere in a ventral position. Frontal process with a moderate conical protrusion covered with a few tuberculate setae carrying a few thin barbs (Fig. 17). The three macrosetae along each side of line of insertion of antennomere and *x* setae with thin distal barbs; length ratios of *a/i/p/x* being 23/27/26/29. Labial palps large and suboval, with a conical latero-external sensillum, two guard setae, up to thirteen setae on anterior border, and up to 250 neuroglandular setae (Fig. 16).

Thorax: Thoracic macrosetae: pronotum with 1+1 *ma*, 3+3 $la_{1\text{-}3}$, 2+2 $lp_{2,4}$ macrosetae; mesonotum with 1+1 ma, 2+2 $lp_{2,4}$ macrosetae; metanotum with 2+2 (2+1; 1+1) $lp_{2,3}$ macrosetae (Figs 18-21). All thoracic macrosetae long and with thin barbs almost all over; thin marginal setae slightly longer than clothing setae, both with thin distal barbs almost all over their surface (Figs 19-21). Legs elongated, metathoracic legs reaching beyond end of abdomen; femur, tibia and tarsus with pretarsus similar in length (Table 3). Femora carrying well-differentiated long subapical ventral macrosetae. Calcars completely covered with thin barbs (Fig. 23). Tarsus with two rows of ventral setae, these similarly barbed but larger than clothing setae, plus several thin long setiform sensilla all over tarsus. Tarsus with three dorsal and two ventral subapical setae with thin barbs all over. Claws unequal in size, posterior claw longer than anterior claw (posterior claw : anterior claw ratio = 1.5-1.6 : 1), both claws with large lateral crests. Ventral side of claws noticeably ridged and covered with a micro-granular surface; posterior claw large, with a backward overhang. Lateral processes of pretarsus setiform, with a few thin proximal barbs (Figs 22, 24-25).

Abdomen: Distribution of abdominal macrosetae on tergites: 1+1 *la* on IV; 1+1 *la*, 1+1 $post_5$ on IV; 1+1 *la*, 3+3 $post_{3,4,5}$ on VI-VII; 5+5 $post_{1\text{-}5}$ on VIII; 8+8 *post* on IX. All tergal abdominal macrosetae long and well-differentiated, with thin barbs in distal four-fifths. Urosternite I with 24+24-21+21 (18+18 in smaller specimen: ♂2 paratype) well-barbed macrosetae (Figs 26-31); urosternites II-VII with 15+15-13+13 (11+11 in smaller specimen = ♂2 paratype) macrosetae (Figs 32-33); urosternite VIII with

Table 3. *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. Length (in mm) of body, antennae, femur, tibia and tarsus of metathoracic legs; number of antennomeres.

specimen	body	antennae	number of antennomeres	femur	tibia	tarsus
♂2 paratype	3.9	4.3	48	0.60	0.63	0.61
♂3 paratype	4.6	5.8	48	0.85	0.86	0.75
♀2 paratype	5.5	-	-	0.95	1.02	1.00
♀12 paratype	5.6	7.0	48	0.94	1.04	0.90
♀3 paratype	5.8	7.1	50	0.97	1.10	0.98
♂1 holotype	5.9	7.1	45	0.94	1.08	0.95
♀13 paratype	6.0	6.8	40	1.00	1.09	0.79
♀4 paratype	6.2	7.6	43	1.08	1.25	1.10
♀8 paratype	6.5	-	-	1.02	1.17	0.99
♀6 paratype	6.6	7.8	41	1.25	1.41	1.10
♀1 paratype	6.7	8.3	44	1.15	1.35	1.05
♀7 paratype	7.4	7.9	41	1.26	1.45	1.08
♀9 paratype	7.5	8.2	45	1.12	1.34	1.11
♀5 paratype	7.6	-	-	1.15	1.28	1.08
♀10 paratype	7.7	-	-	1.15	1.35	1.10
♀11 paratype	8.7	-	-	1.30	1.58	1.13

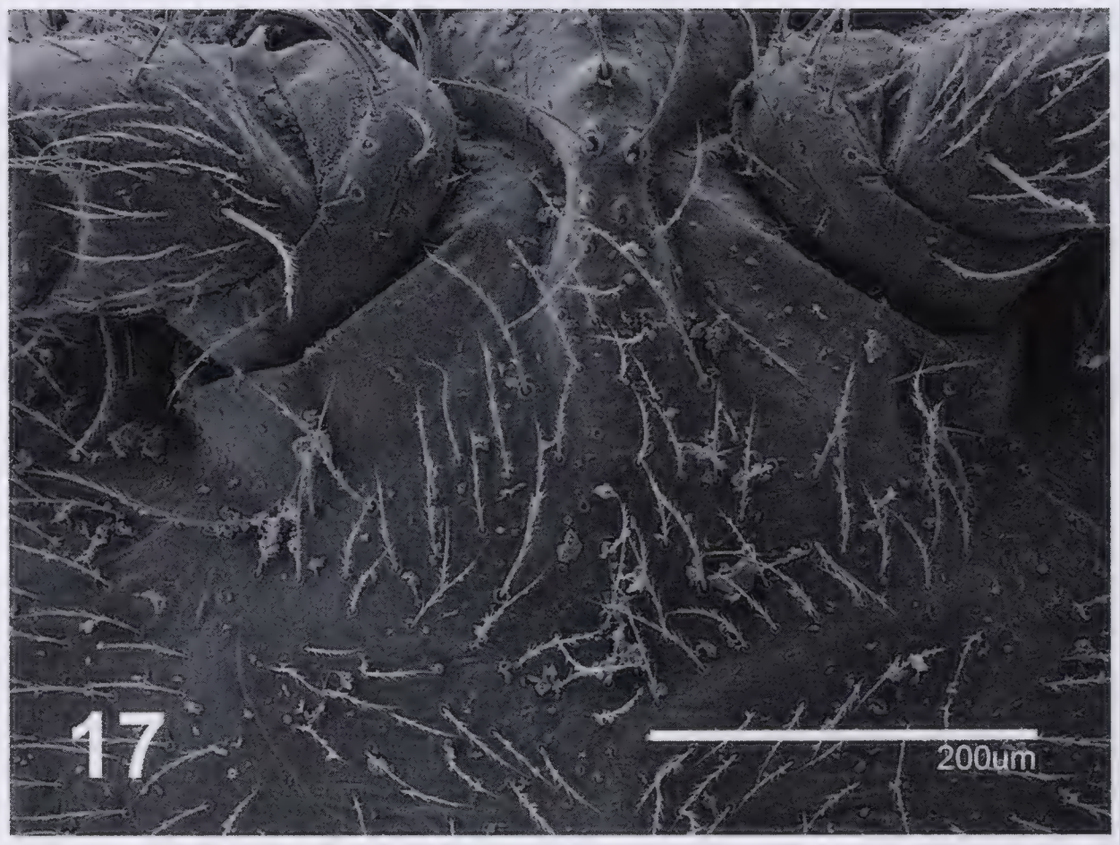


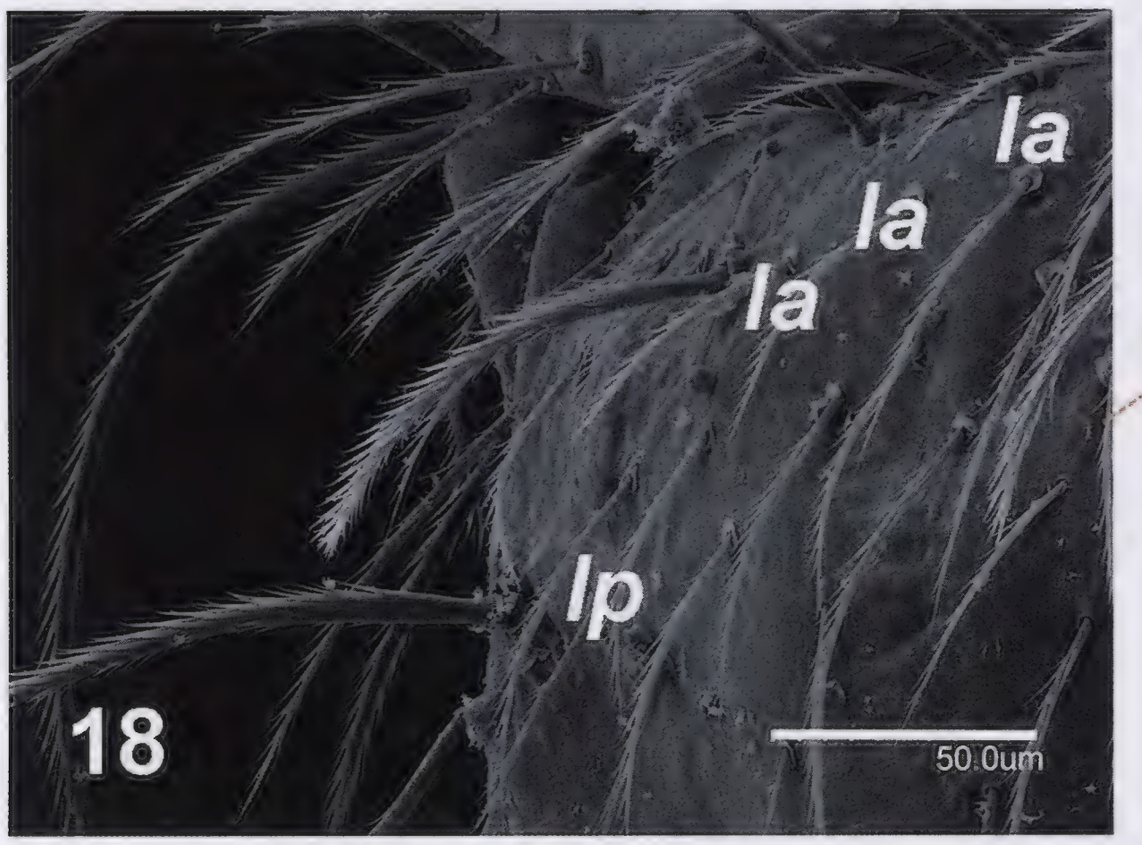
Figs 12-15. *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. (12) Apical view of last antennomere with narrow hole of cupuliform organ. (13) Medial antennomeres. (14) Lateral distal detail of a medial antennomere with gouge sensilla (*g*). (15) Lateral distal portion of a medial antennomere with gouge sensilla (*g*) and one conical sensillum (c*s*).

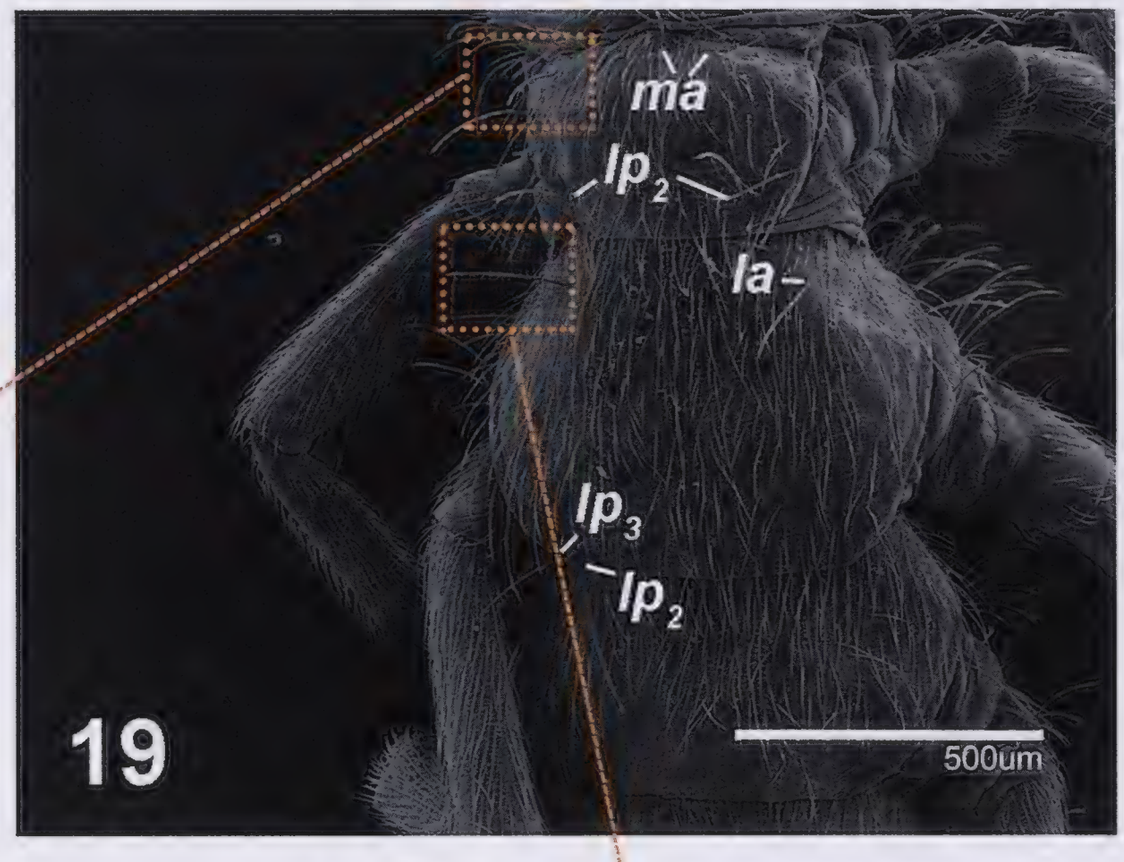
3+3-4+4 macrosetae (Fig. 36); urosternal macrosetae of medium length or longer and with long barbs, some divided into micro-barbs all over distal two-thirds (Figs 28-29, 33). Stylar apical setae including a long basal tooth, subapical setae completely covered with barbs all around; medial setae thinner than others, with short barbs in distal two-thirds (Figs 34, 37). Eversible vesicles large, with two different surface textures (Figs 34-35). No intact cerci available in studied material; the most complete cercus present on ♀6 paratype: basal article with 12 secondary articles followed by 18 primary articles, total length 12 mm. Length of cercal articles increasing from proximal to distal articles. Each article with a variable number of irregular whorls of almost completely barbed macrosetae, from three on proximal articles to 18 on distal articles, mixed with few irregular whorls of long smooth setae. All primary articles with a short, thin, distally barbed whorl of seta (Figs 38-39).

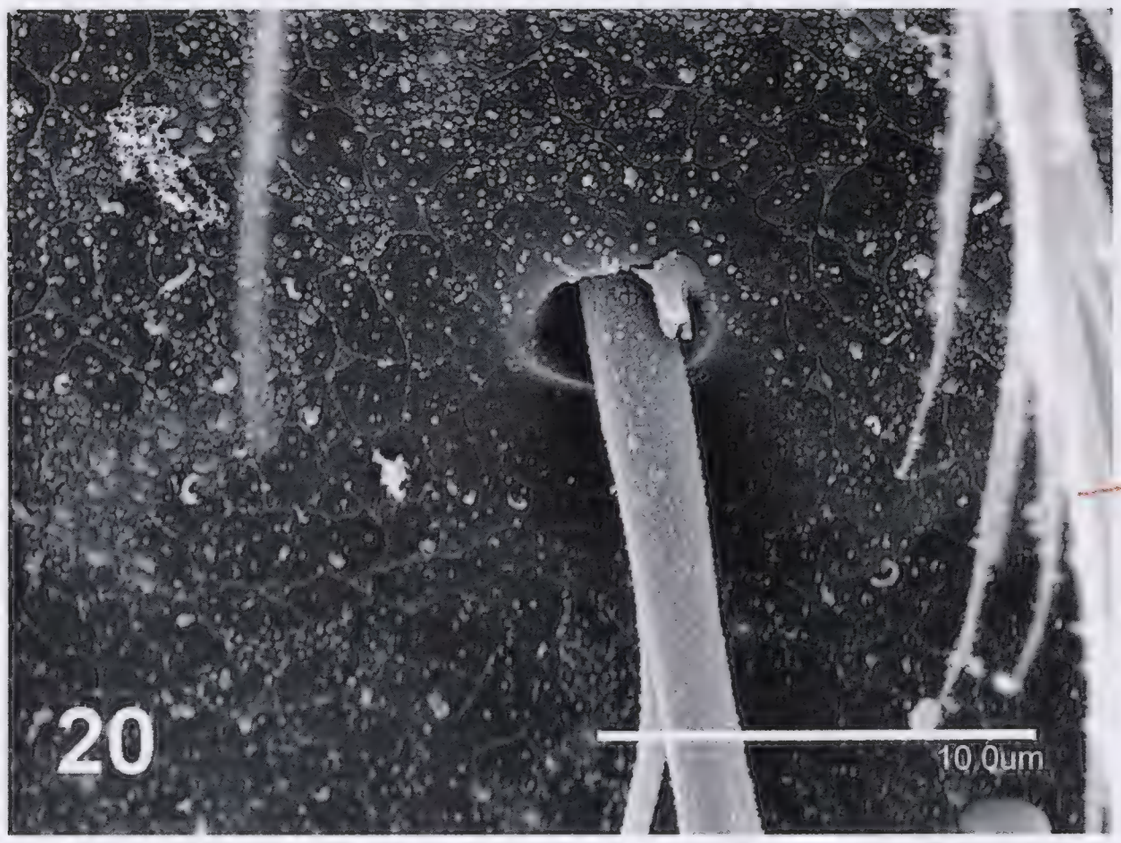
Secondary sex characters: Female urosternite I with subcylindrical appendages, each one bearing up to 17 glandular a_1 setae in a distal field (Figs 30-31). Male urosternite I with enlarged appendages, each one bearing up to 80 glandular a_1 setae in a distal field; posterior edge of urosternite I with a field of up to 240 glandular g_1 setae arranged in four rows; additionally about eighty short setae in an anterior position, these clearly differentiated from clothing setae by their barbed middle portion (Figs 26-27).

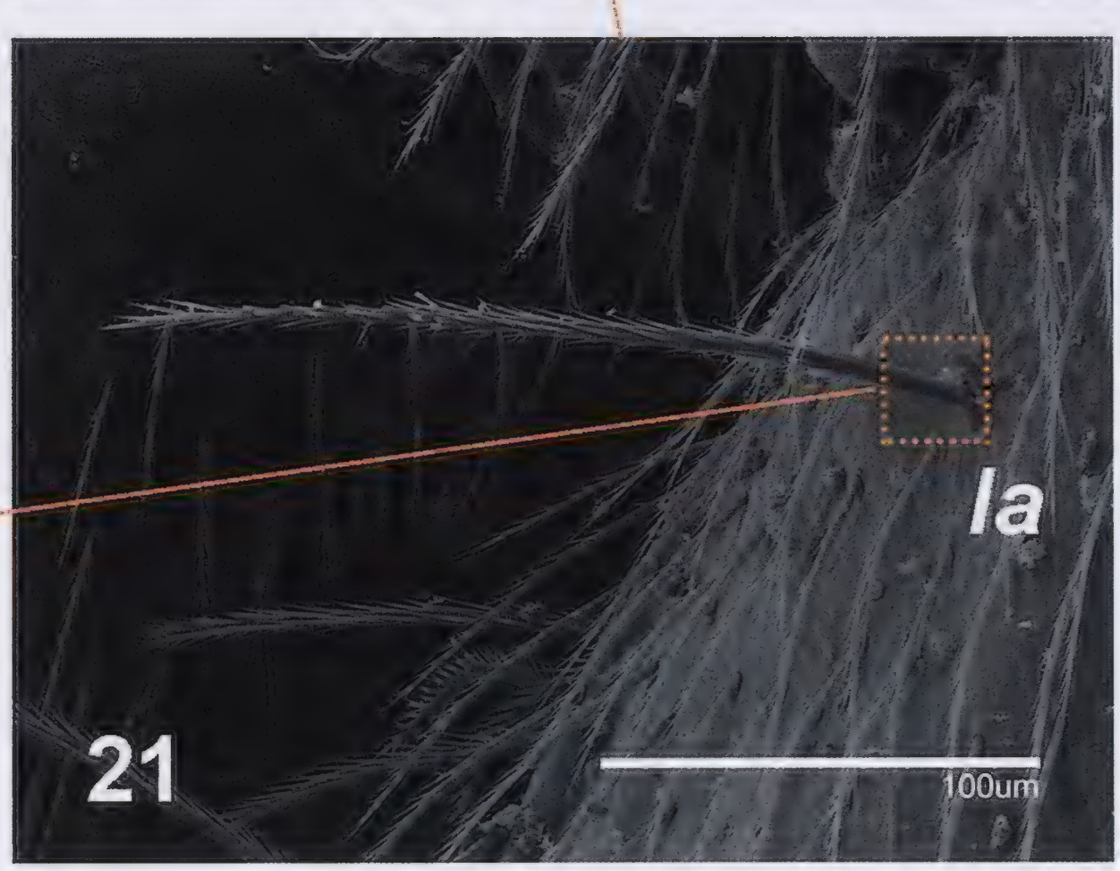
Taxonomic affinities: More than two decades ago, Condé & Bareth (1996) referred to one male and two females sampled in the Vranjača pećina Cave near Kotlenice (Split, Croatia) as *Plusiocampa (Stygiocampa)* cf. *remyi* because of differences in secondary sex characters of the male. These traits consist of enlarged appendages with a large apical field of glandular a_1 setae and a large field of glandular g_1 setae on the posterior border (Figs 26-31). The same structures are found in four males collected in the



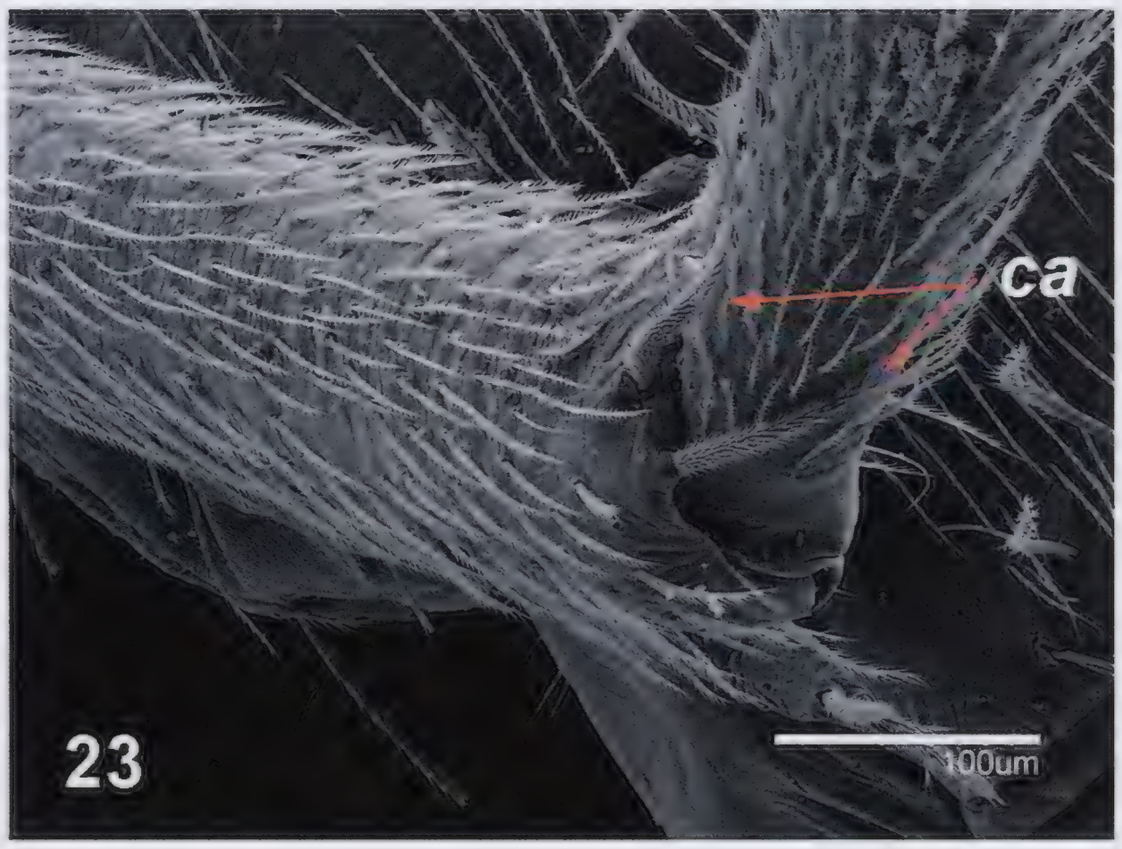


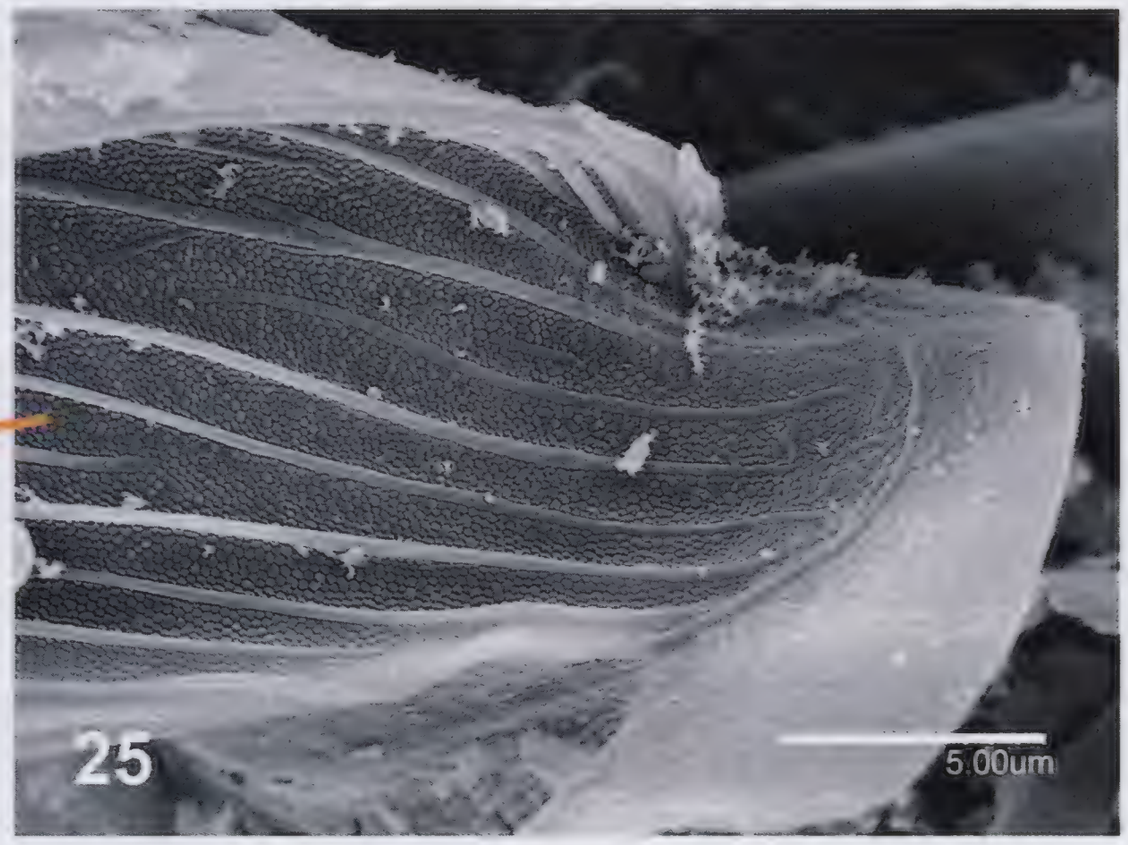






Figs 16-21. *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. (16) Head, ventral view. (17) Frontal process, dorsal view. (18) Lateral left side of prothorax, dorsal view. (19) Prothorax, mesothorax and metathorax, dorsal view. (20) Detail of surface and insertion of lateral anterior mesonotal macroseta. (21) Lateral anterior portion of mesonotum.





Figs 22-25. *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. (22) Pretarsus, dorso-lateral view. (23) Joint between tibia and tarsus with calcars (*ca*). (24) Pretarsus, lateral view (*i* = intermediate sheet). (25) Detail of ventro-lateral portion of anterior claw.

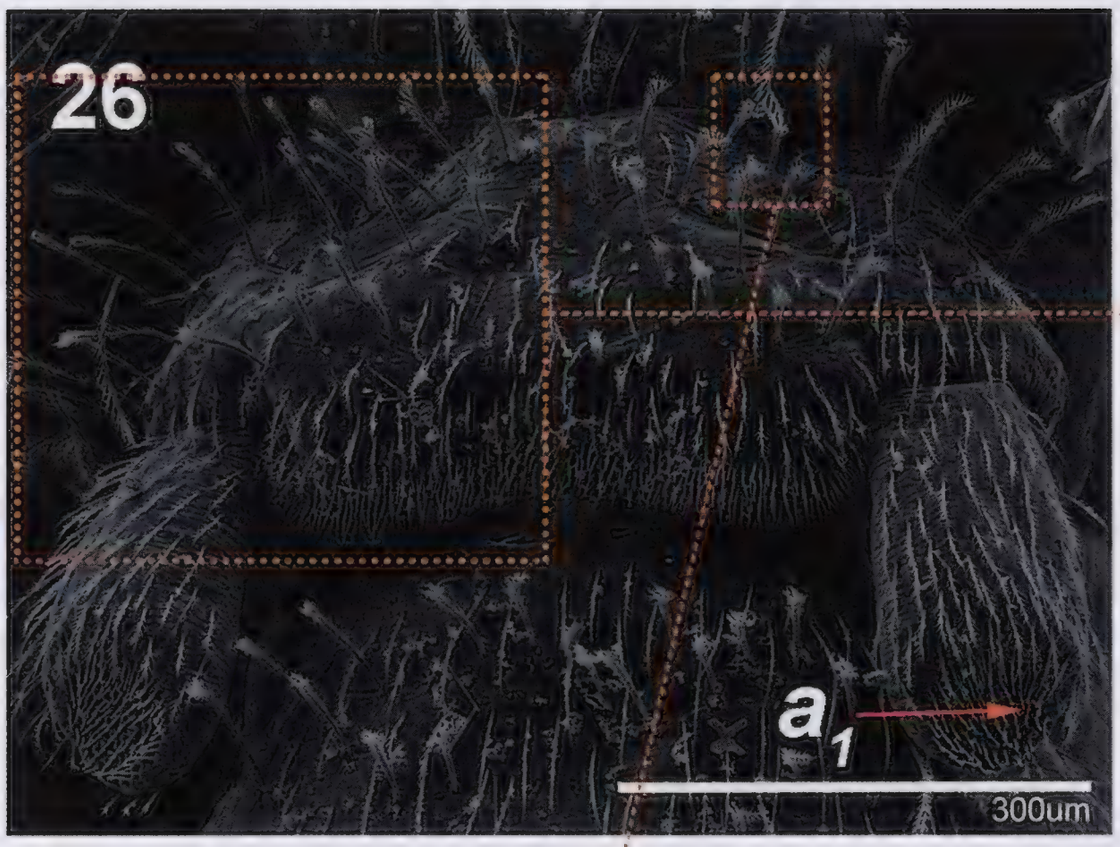
nearby Grabovčića jama Cave (Radošić, Croatia). This morphological distinction encouraged us to propose a new species from the Vranjača pećina and Grabovčića jama specimens, i.e. *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. In addition to the characters mentioned above, there are several other differences between *P. (S.) barethae* sp. nov. and *P. (S.) remyi,* such as shorter and thinner gouge sensilla in *P. (S.) remyi*; 1+1 lateral anterior macrosetae on third urotergite in *P. (S.) remyi,* which are absent in *P. (S.) barethae* sp. nov.; and 9+9 to 11+11 posterior macrosetae on the ninth abdominal segment in *P. (S.) remyi* instead of 8+8 posterior macrosetae as in *P. (S.) barethae* sp. nov.

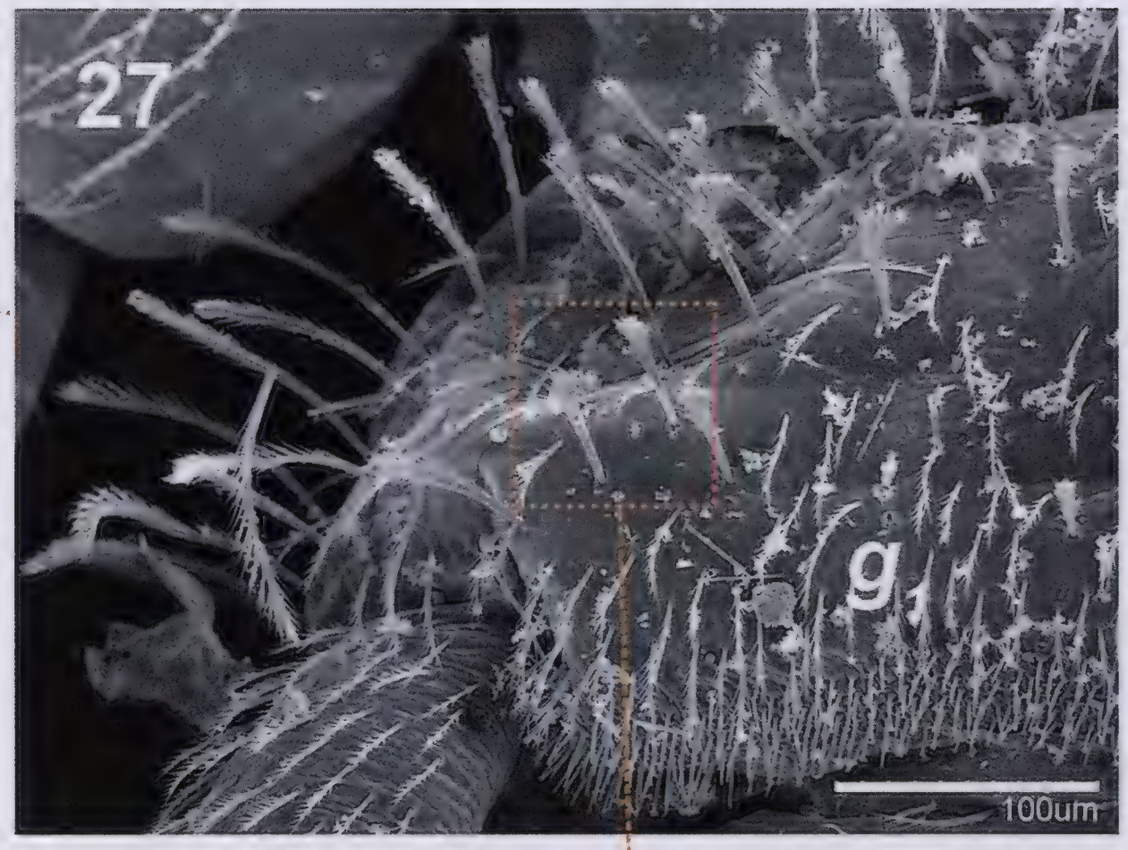
Type locality: The Grabovčića jama Cave, with a narrow, approximately 1 x 0.6 m wide entrance, is situated at 230 m a.s.l (Fig. 40). The bottom, at 45 m depth, is reached through a series of small pits. The interior of the cave is humid, with an annual mean temperature of about 10°C. The specimens were collected on flowstone at a depth of approximately 30 m (Fig. 41), in complete darkness. More than ten individuals of different sizes were spotted on our third visit to the cave.

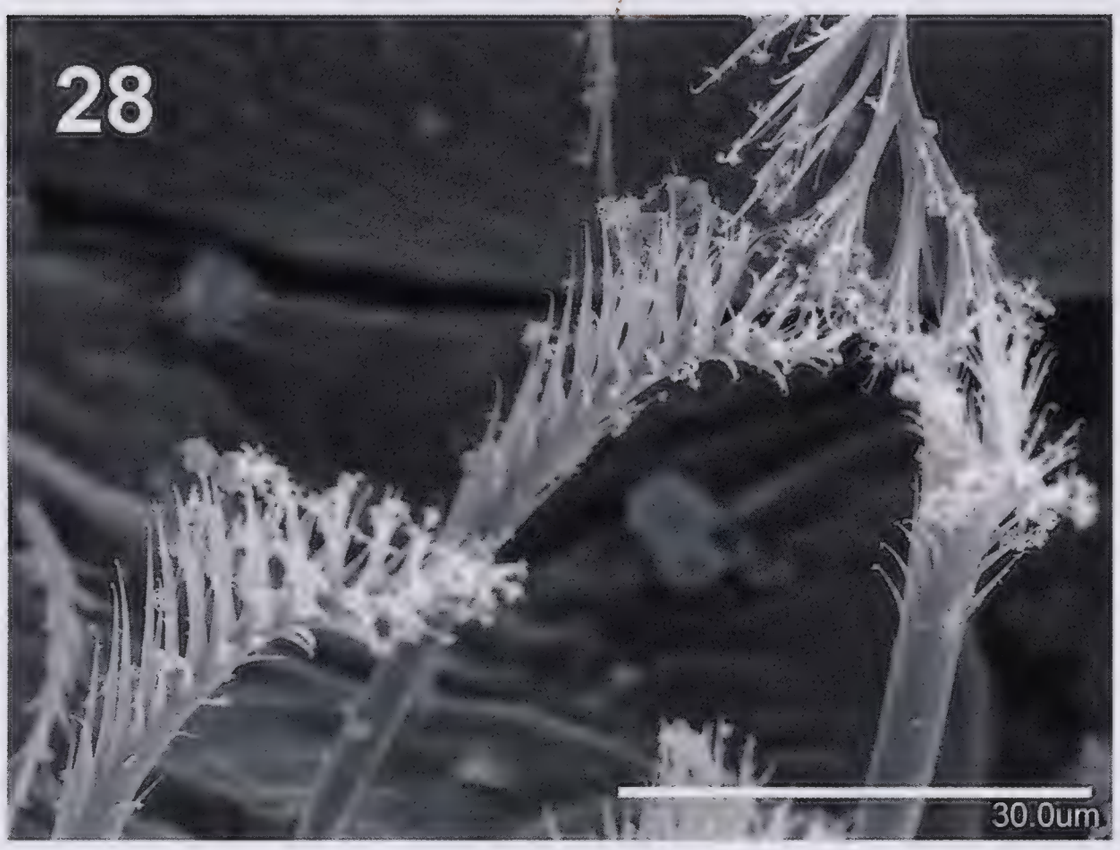
Plusiocampa (Stygiocampa) christiani Condé & Bareth, 1996

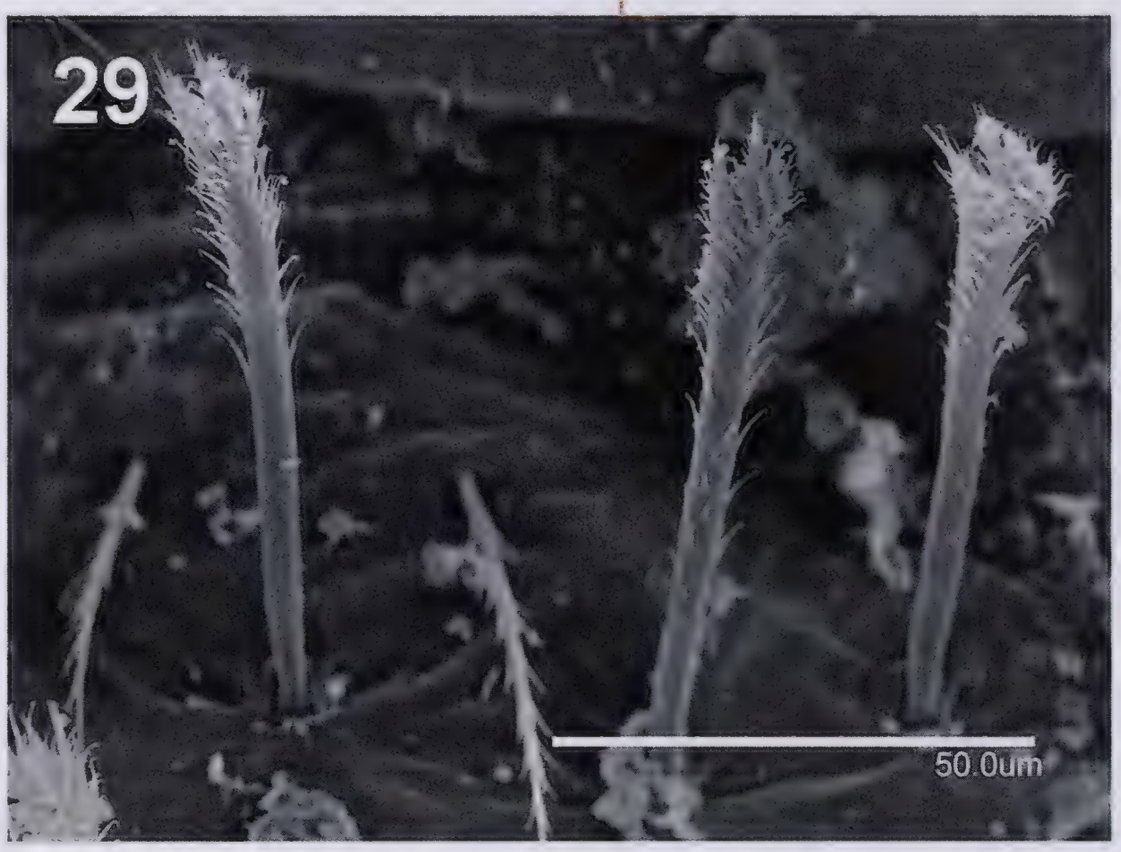
Figs 44-61

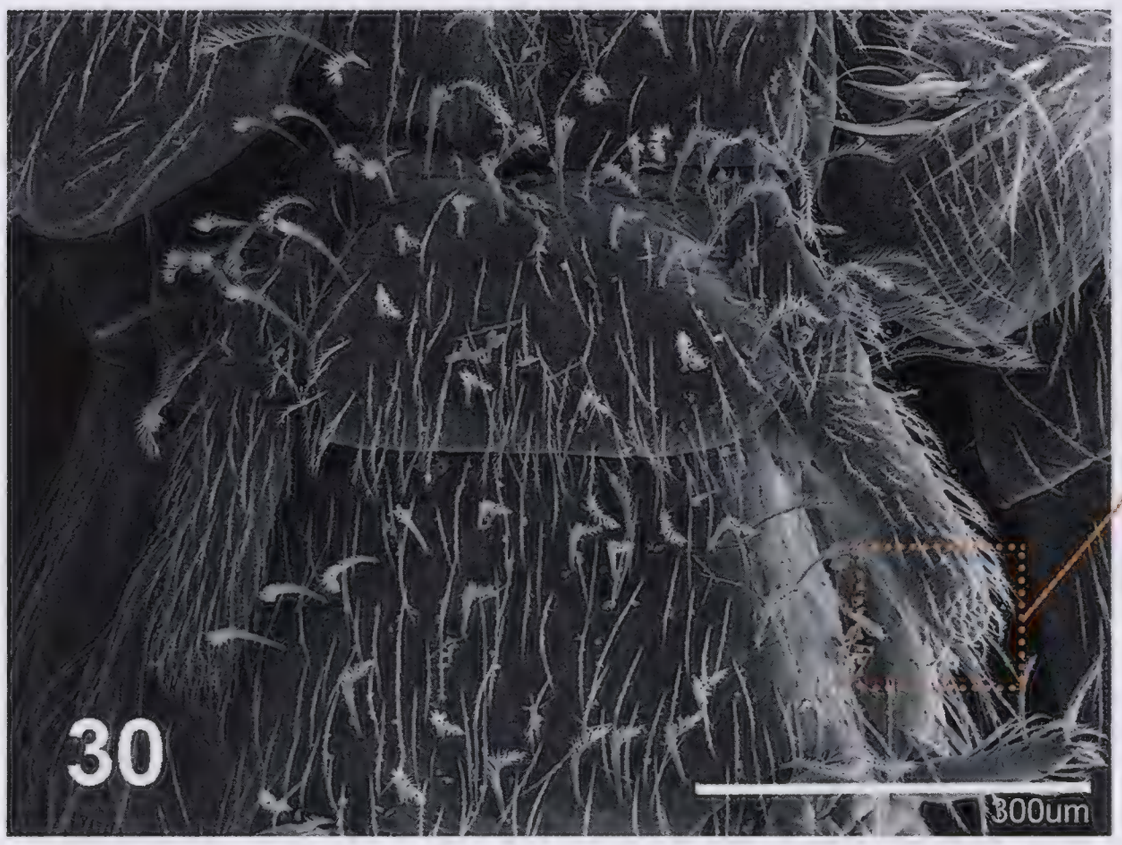
Material studied: Coll. AS; one male and thirteen females; Serbia, Izviđačka Cave, canyon of the river Suvaja, Mt Beljanica, near Despotovac; 14th July 2018; leg Đ. Marković. – Coll. AS; one male and five females; from the same cave; 6th June 2018; leg. S. Ćurčić. – Coll. AS; two females and one juvenile; Serbia, Vlaška Cave, Mt Beljanica; 11th April 2010; leg. I. Njunjić. – Coll. AS; three females; Serbia, Lazareva (Zlotska) Cave, village of Zlot, Kučaj Mts, near Bor; 15th November 2018; leg. D. Antić, D. Stojanović. – Coll. AS; three females; Serbia, Lazareva (Zlotska) Cave,

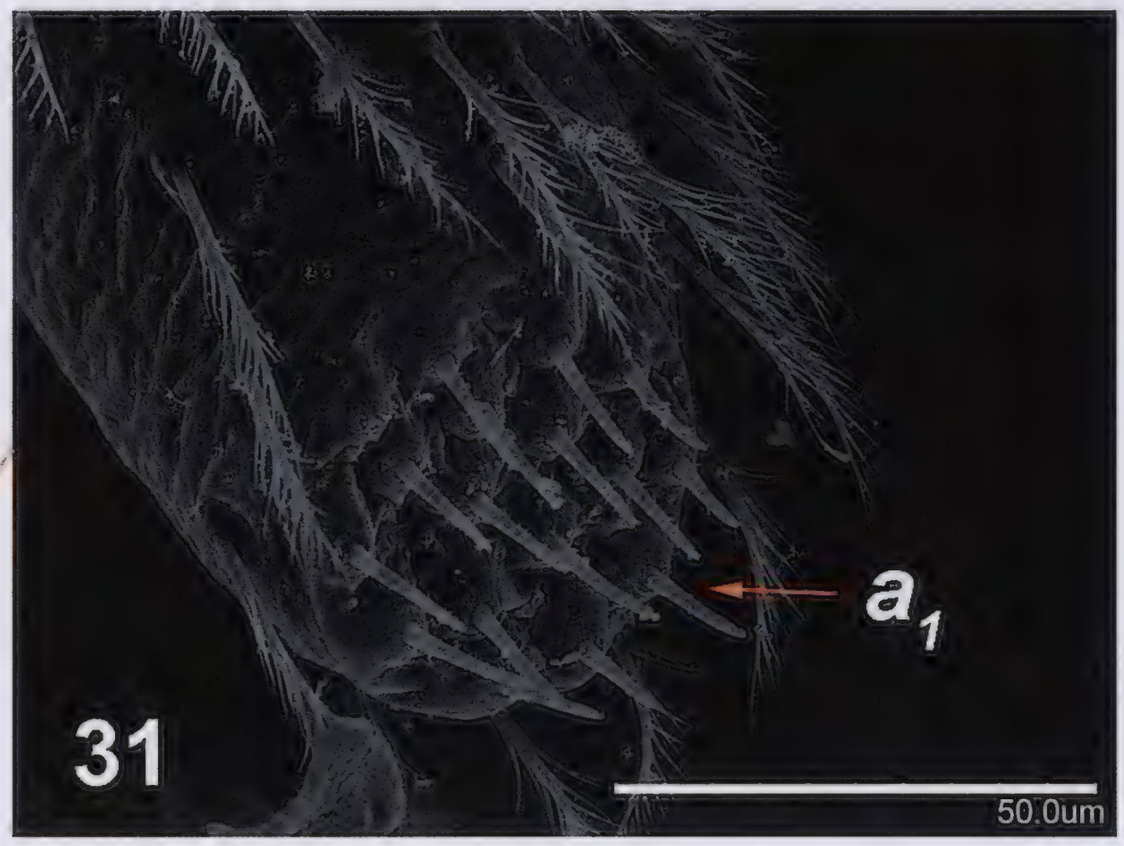




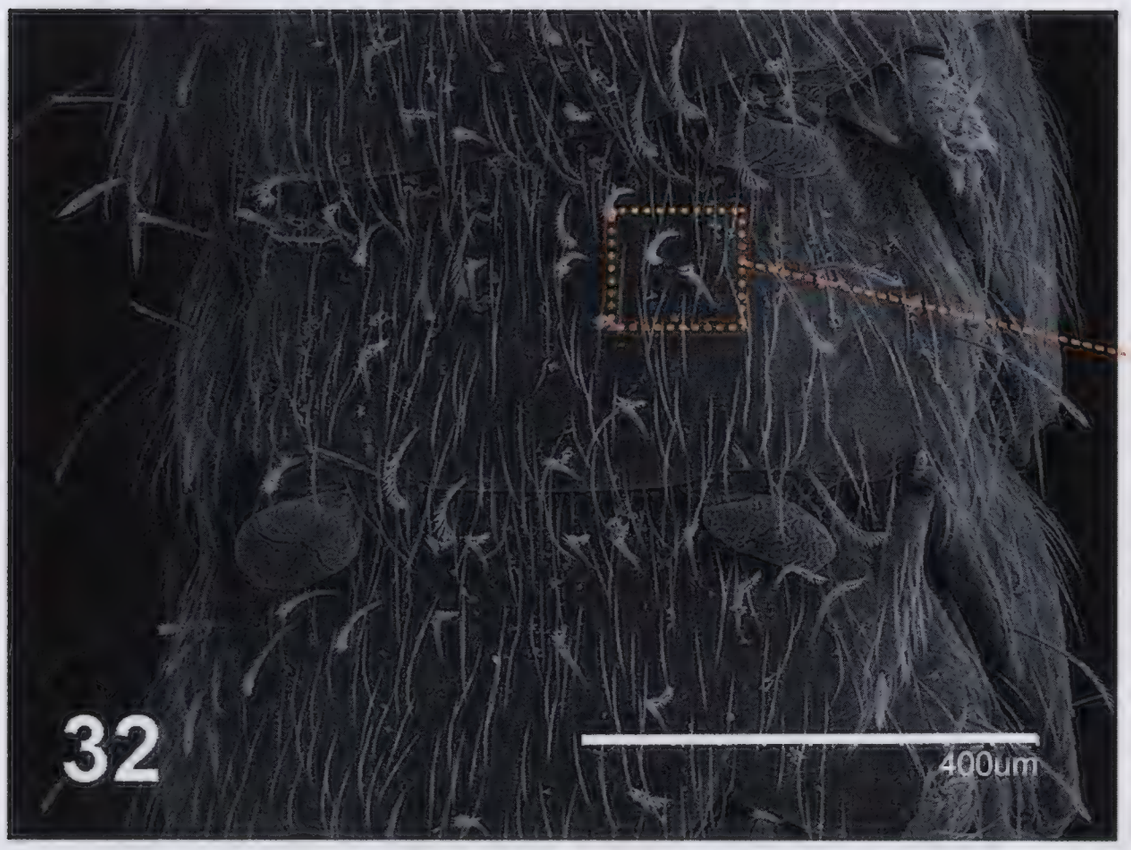


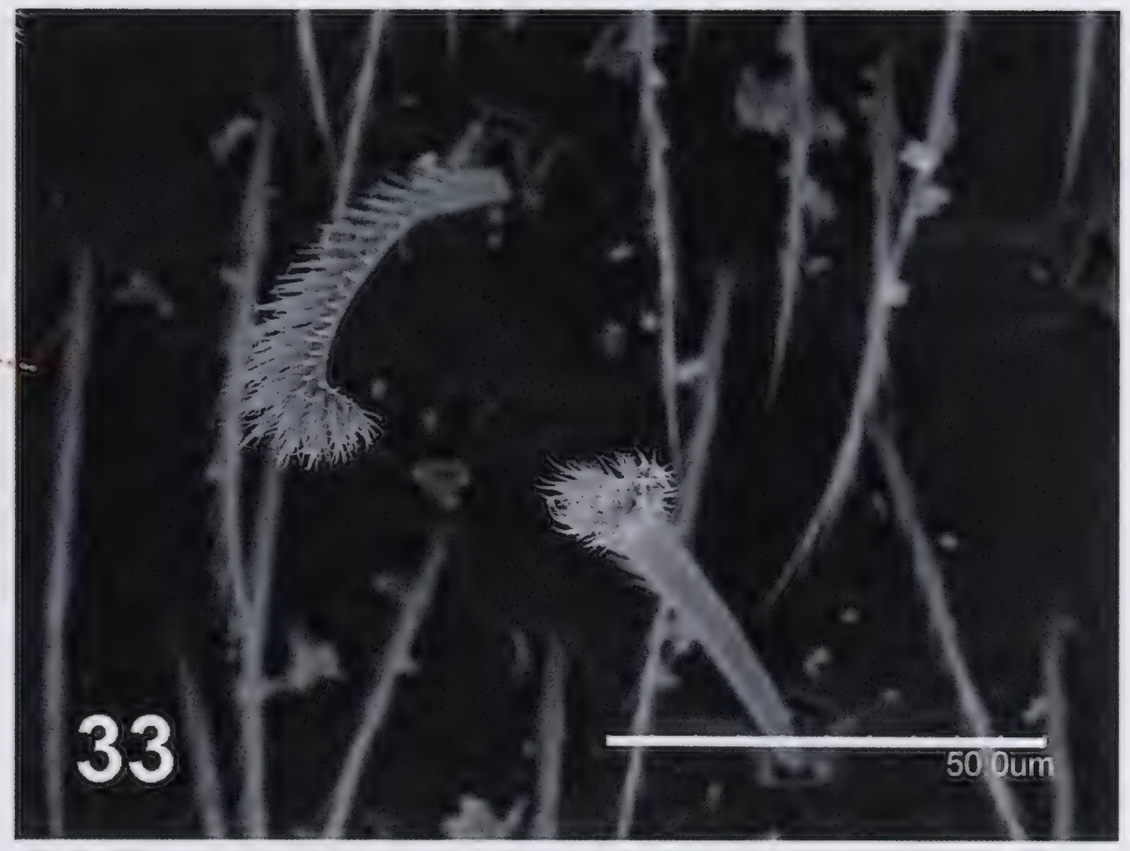


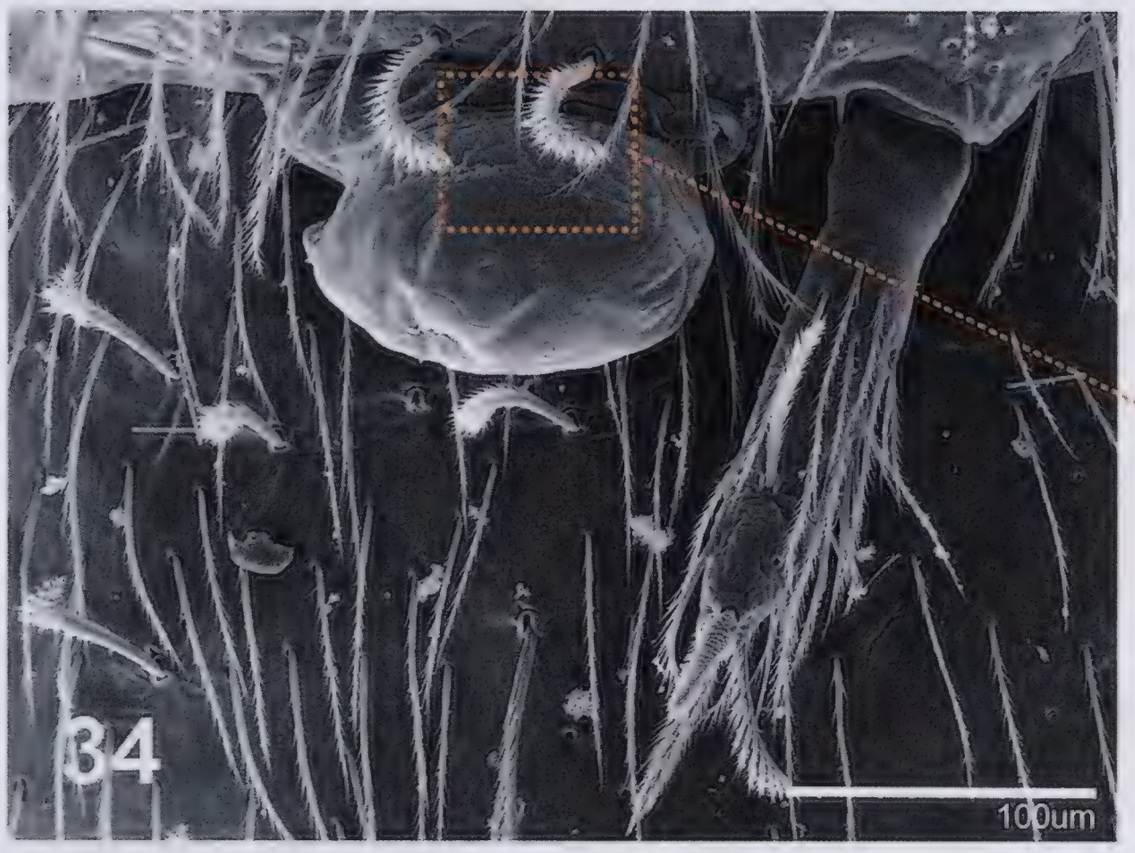


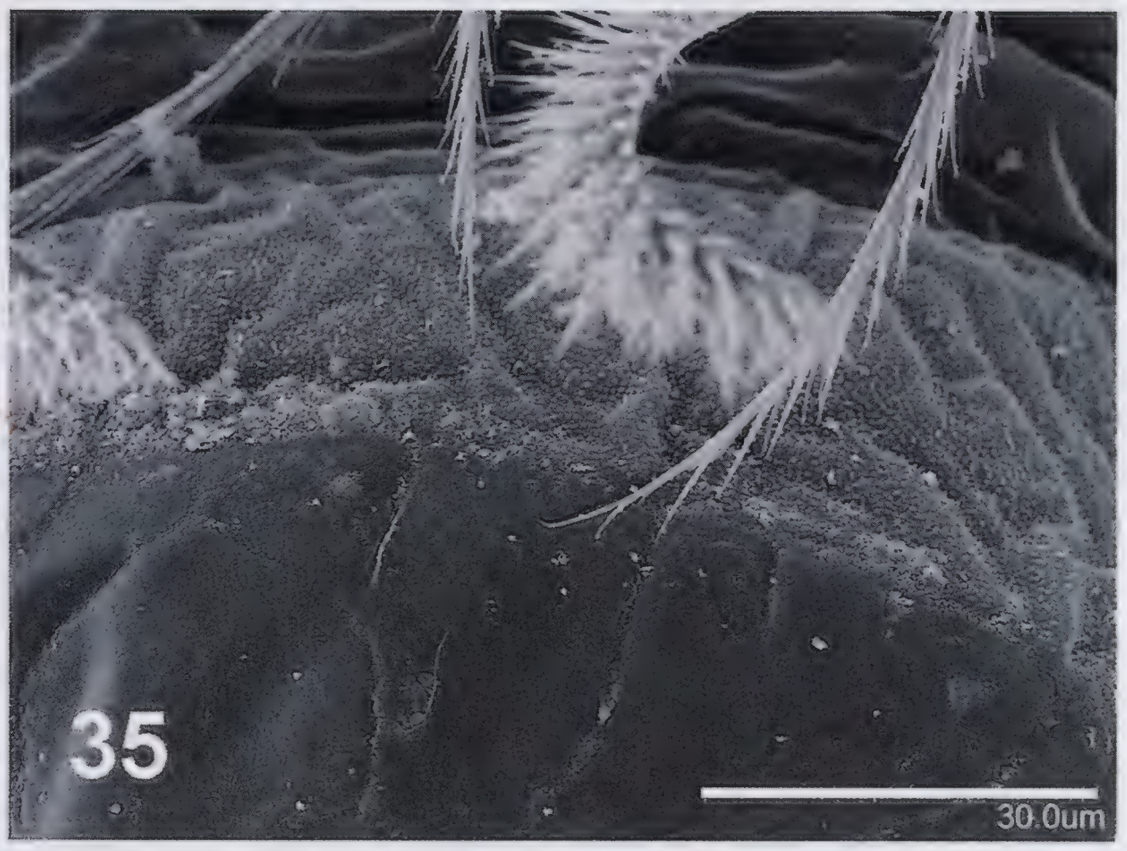


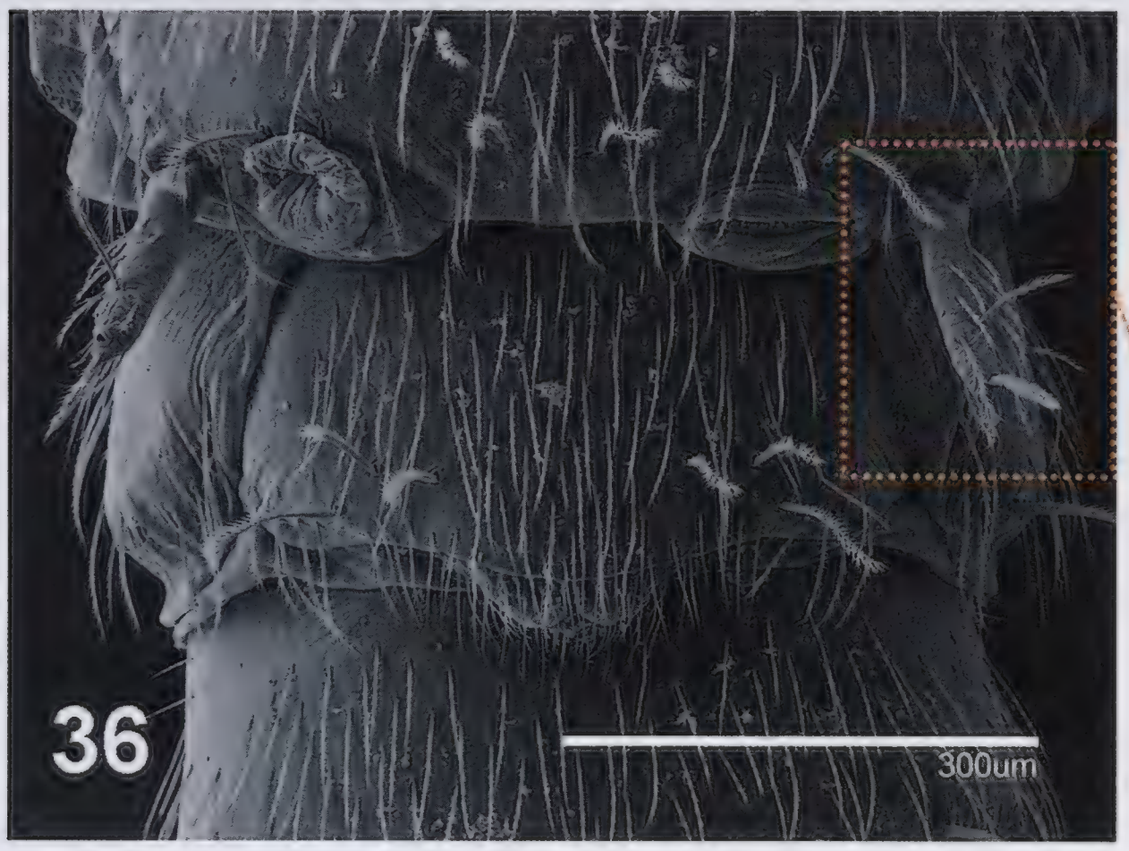
Figs 26-31. *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. (26) First and anterior portion of second urosternites of an adult male. (27) Lateral right side of first urosternite of an adult male. (28) Distal part of urosternal macrosetae. (29) Urosternal macrosetae. (30) First and anterior portion of second urosternites of an adult female. (31) Distal portion of one appendage of first urosternite of an adult female.



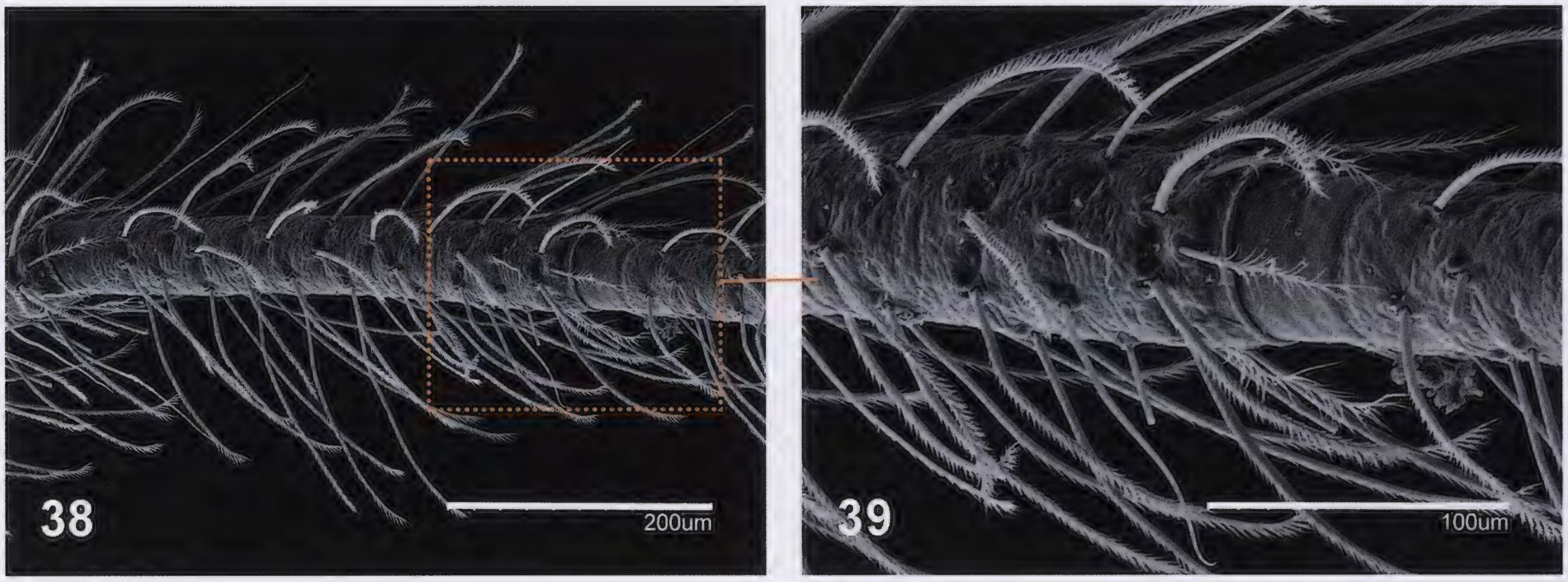








Figs 32-37. *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. (32) Posterior portion of fourth to sixth abdominal segment, ventral view. (33) Detail of macrosetae on fifth abdominal segment. (34) Lateral posterior portion of sixth urosternite. (35) Detail of eversible vesicle with two different kinds of surface microstructures. (36) Posterior portion of seventh abdominal segment to anterior portion of ninth abdominal segment, ventral view. (37) Left stylus of eighth abdominal segment, ventral view.



Figs 38-39. *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. (38) Fourth primary cercal article. (39) Detail of distal portion of fourth primary cercal article.

village of Zlot, Kučaj Mts, near Bor; 16th June 1996; leg. S. Ognjenović. – Coll. AS; one female; Serbia, Jama u Vrtačelju Pit, Vrtačelje, Kučaj Mts; 17th October 2007; leg. S. Ognjenović. – Coll. AS; three females and six specimens; Serbia, Vernjikica Cave, village of Zlot, Kučaj Mts, near Bor; 15th November 2018; leg. D. Antić, D. Stojanović. – Coll. AS; three females; Serbia, Bogovinska Cave, village of Bogovina, Kučaj Mts, Boljevac; 16th November 2018; leg. D. Antić, D. Stojanović.

Taxonomic notes: SEM observations have revealed and supplemented some taxonomic features, such as a narrow hole of the cupuliform organ (Fig. 44); very long shafts of trichobothria (Fig. 45); a quadrangular protruding frontal process with non-tuberculated setae (Figs 46-47); thin and long neuroglandular setae on subspherical labial palps with enlarged asymmetrical openings (Figs 48-49); slightly elongated nota with macrosetae on pronotum (1+1 *ma*, 3+3 *la*, 1+1 lp_2), a lack of macrosetae on mesonotum and metanotum with a microreticulated surface visible under SEM (Figs 50-53); tibia with barbed calcars (Fig. 56); claws unequal (posterior claw: anterior claw ratio = 1.45 : 1); tarsal setae with long barbs from base to tip; dorsal surface of claws almost smooth, longitudinal grooves on ventral side with a pattern of tiny transversal ridges between them (Figs 54-55, 57); first urosternite of females carrying subcylindrical appendages ending in a small field of glandular a_1 setae (Figs 58-59); long urosternal macrosetae with long, thin barbs in half to three-fourths of distal portion (Figs 58, 60); styli carrying short apical setae with a few long barbs, and longer subapical and medial setae with long barbs almost from base to tip (Fig. 61); large eversible vesicles with two well-differentiated areas (Fig. 61).

Biogeographical note: The new localities of the material studied slightly enlarge the previously known geographical range.

Plusiocampa (Stygiocampa) dalmatica Condé, 1959

Material studied: Coll. AS; one juvenile; Montenegro, Začirska Cave, village of Začir, near Rijeka Crnojevića, Cetinje; 25th June 2018; leg. D. Antić, Đ. Marković. – Coll. AS; one female; Bosnia & Herzegovina, Jazvina Cave, Kamešnica; 1st July 2018; leg. T. Rađa.

Taxonomic note: The female from Jazvina Cave is without medial anterior macrosetae on its metanotum.

Biogeographical note: The new localities of the material studied slightly enlarge the previously known geographical range.

Plusiocampa (Stygiocampa) dulcici Sendra & Rađa, sp. nov.

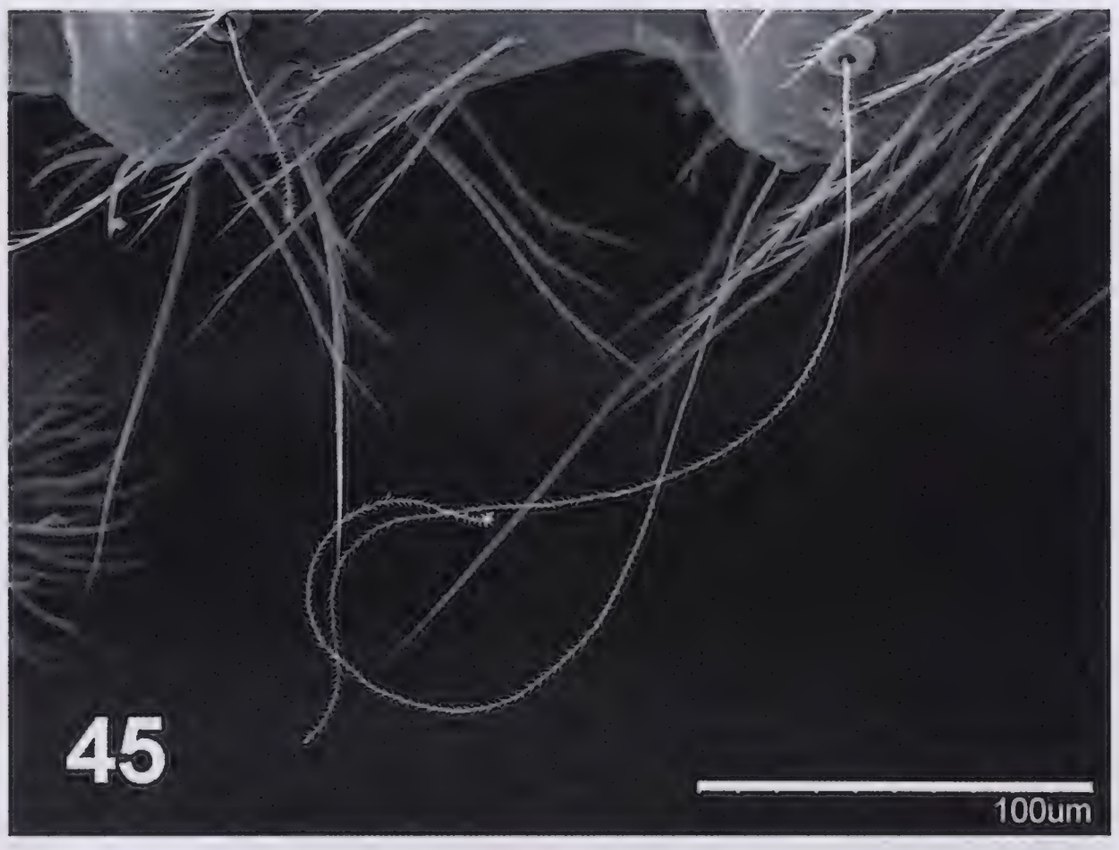
Figs 42-43, 62-76

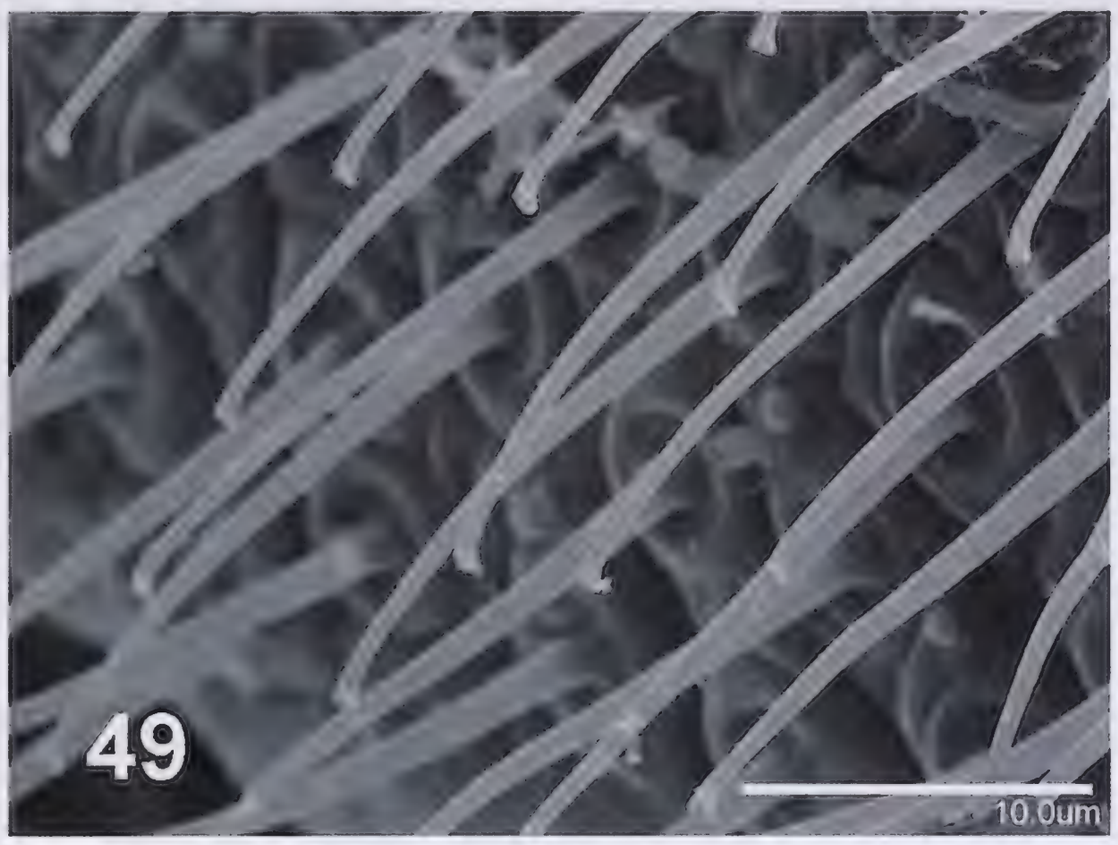
Type material: MHMZOO; female holotype; Croatia, Golubinka pod Kraljevcom Cave, Radošić; 10th September 2014; leg. T. Rađa. – MHNG; one male paratype (labelled ♂1 paratype); same cave and collector; 15th November 2014. – Coll. AS; one male paratype (labelled ♂2 paratype); same cave and collector; 18th April 2014. All material mounted in Marc André II solution.

Other studied material: Coll. AS; two specimens of unknown sex; collected together with holotype; mounted on an aluminium stub and coated with palladium-gold.

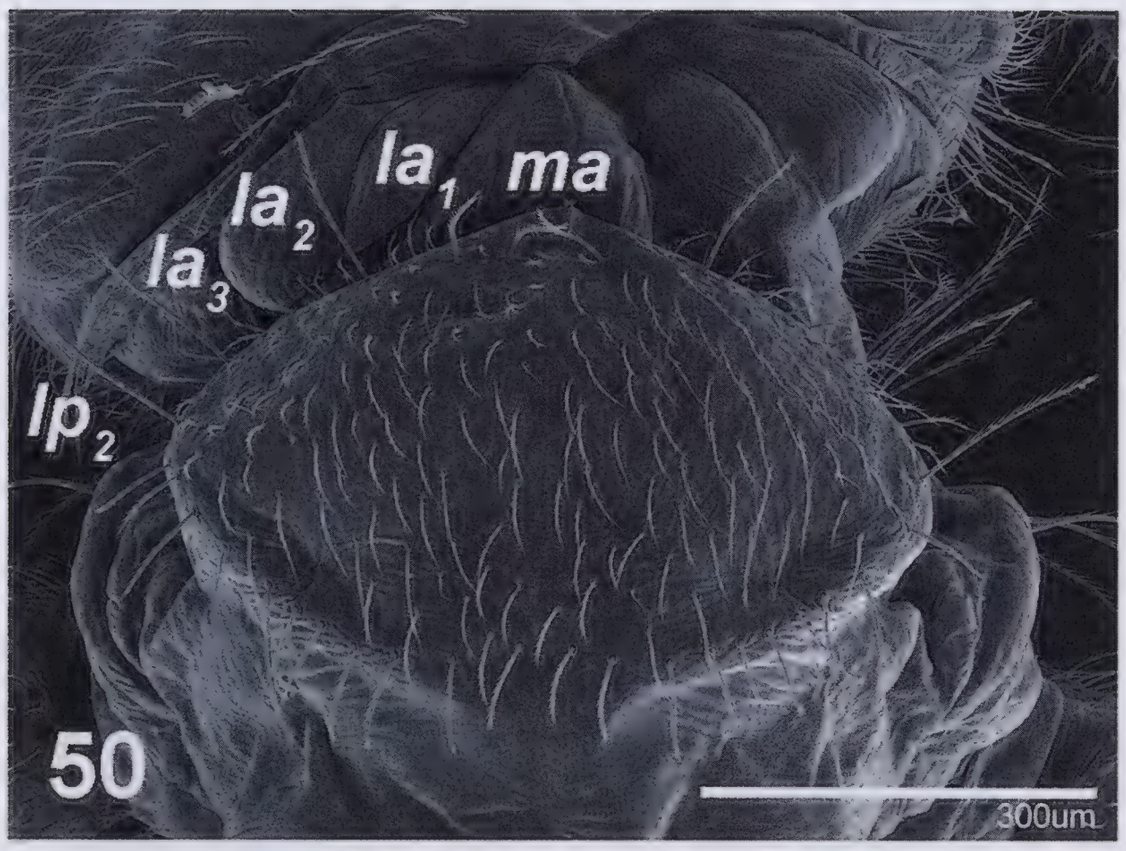
Etymology: This species is named after Vicko Dulčić

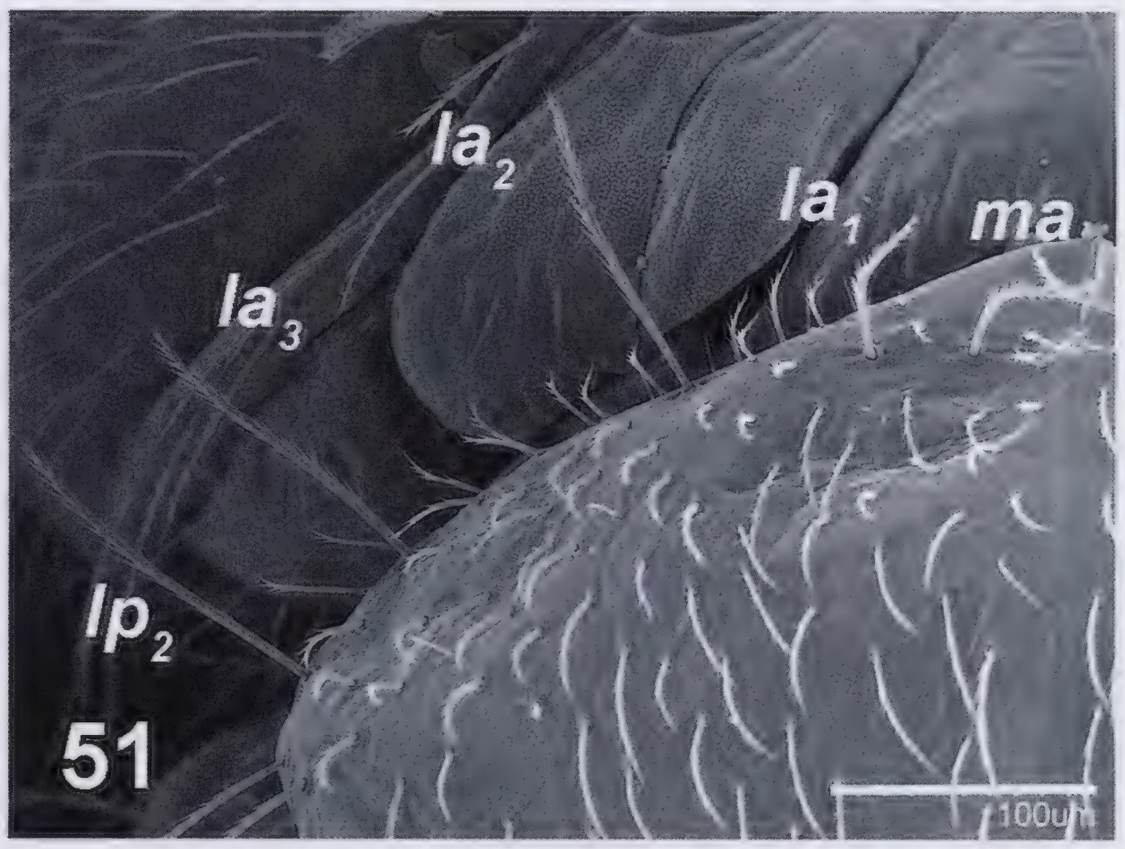
Figs 40-43. Type localities of *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. and *Plusiocampa (Stygiocampa) dulcici* Sendra & Rađa, sp. nov. (40) Narrow entrance of Grabovčića jama Cave, Radošić, Croatia; type locality of *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. (41) Flowstone where *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. was collected at approximately 30 m depth in the Grabovčića jama Cave. (42) Stony surface where *Plusiocampa (Stygiocampa) dulcici* Sendra & Rađa, sp. nov. was collected under small stones at 22 m depth in the Golubinka pod Kraljevcom Cave. (43) Entrance of the Golubinka pod Kraljevcom Cave, Radošić, Croatia; type locality of *Plusiocampa (Stygiocampa) dulcici* Sendra & Rađa, sp. nov.

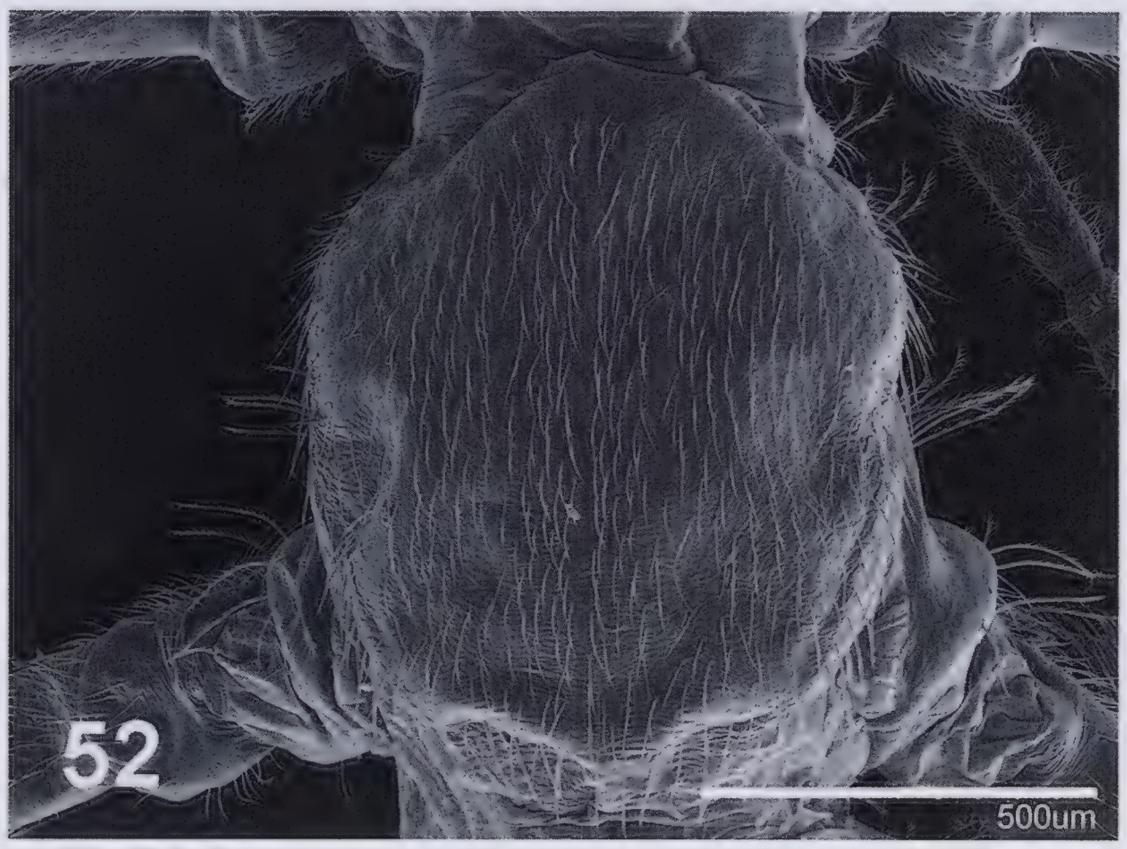


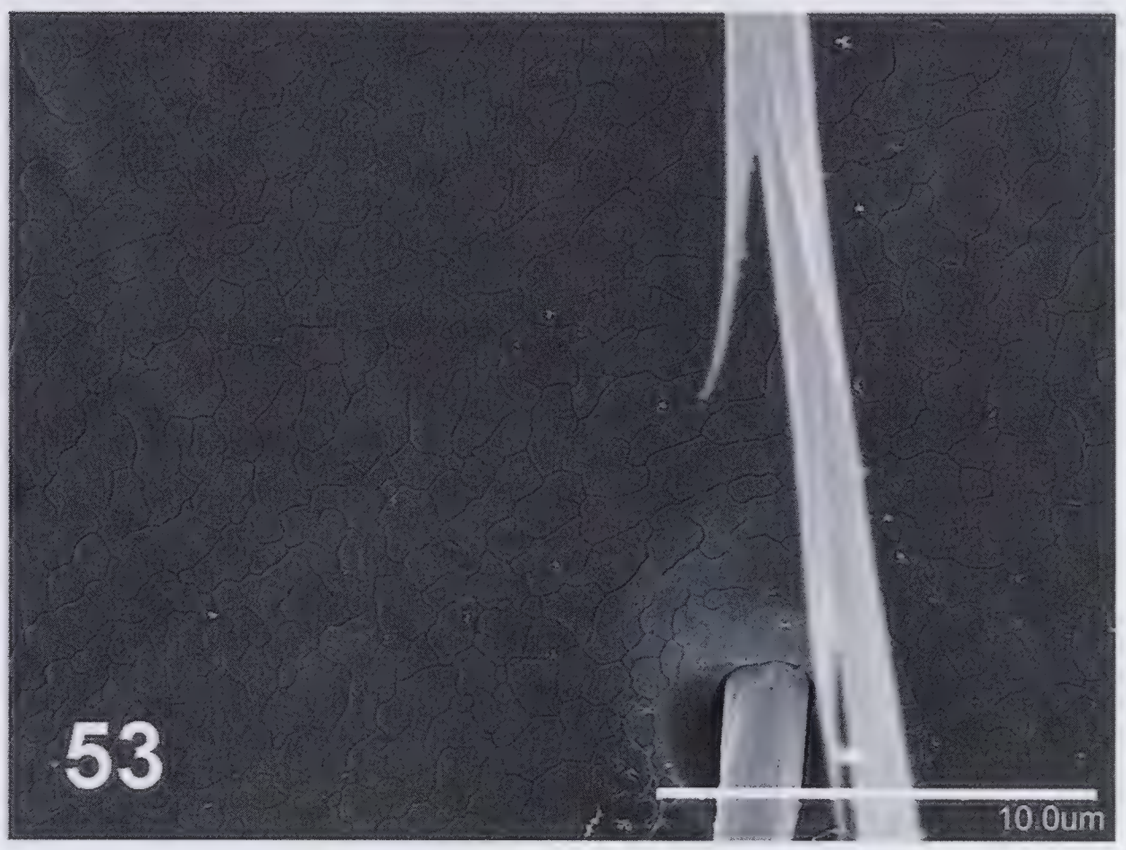


Figs 44-49. *Plusiocampa (Stygiocampa) christiani* Condé & Bareth, 1996. (44) Apical view of last antennomere with hole of cupuliform organ. (45) Lateral view of third and fourth antennomeres with their trichobothria. (46) Anterior frontal view of head. (47) Dorsal view of head. (48) Labial palp. (49) Detail of labial palp.









Figs 50-53. *Plusiocampa (Stygiocampa) christiani* Condé & Bareth, 1996. (50) Prothorax, dorsal view. (51) Lateral left view of dorsal side of prothorax. (52) Mesothorax, dorsal view. (53) Detail of surface of mesothorax.

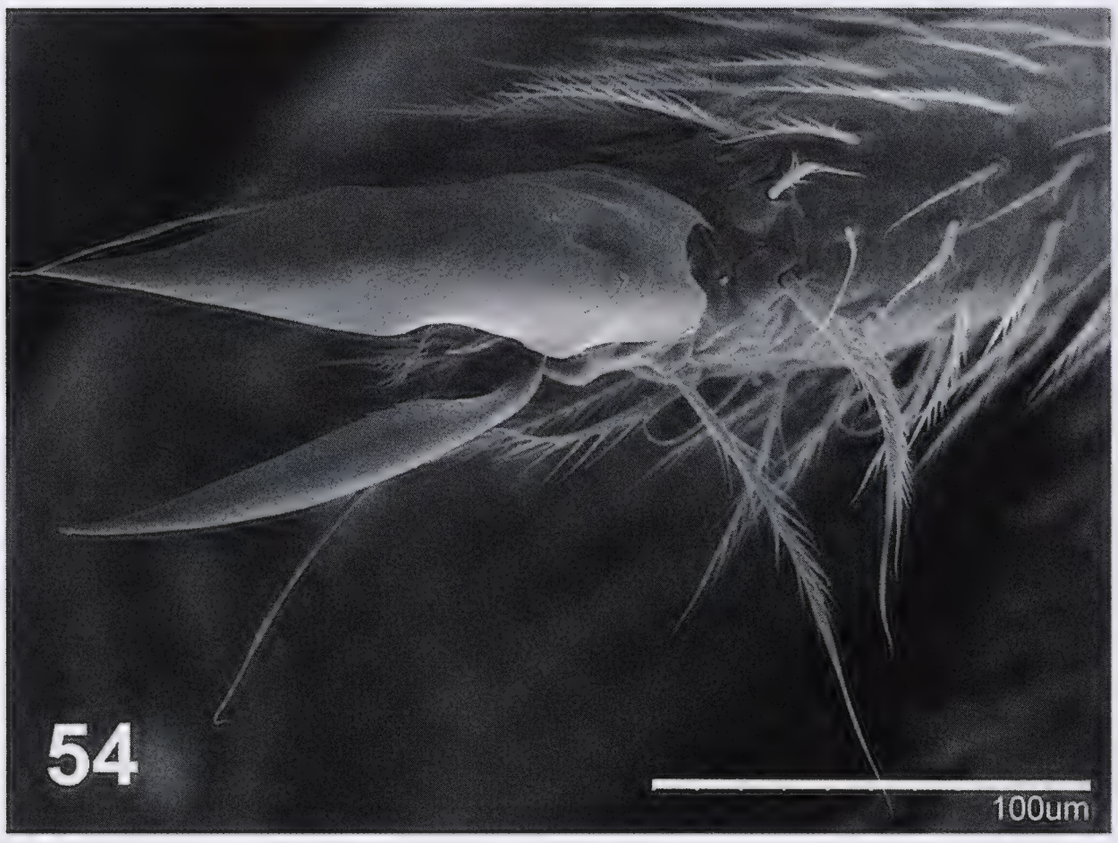
(1923-1985), a Croatian caver and founder of the Speleological Society "Špiljar", Split, Croatia. Name in the genitive case.

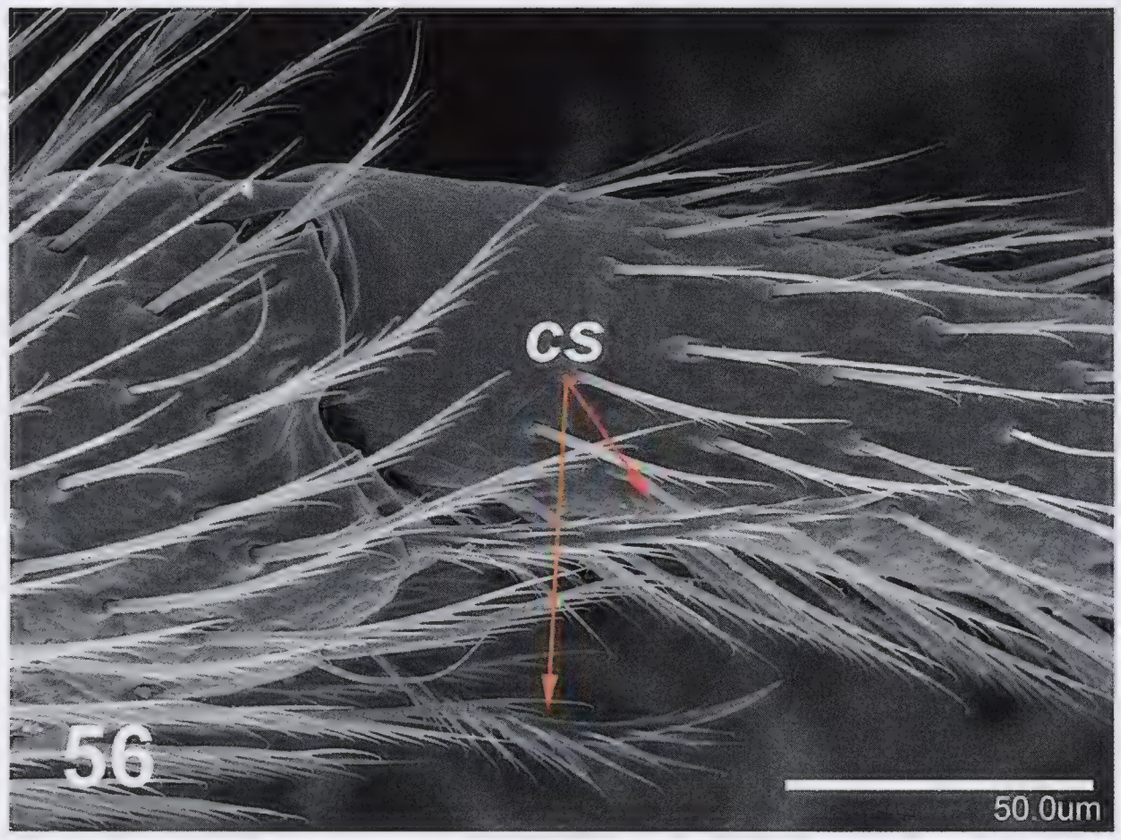
Description:

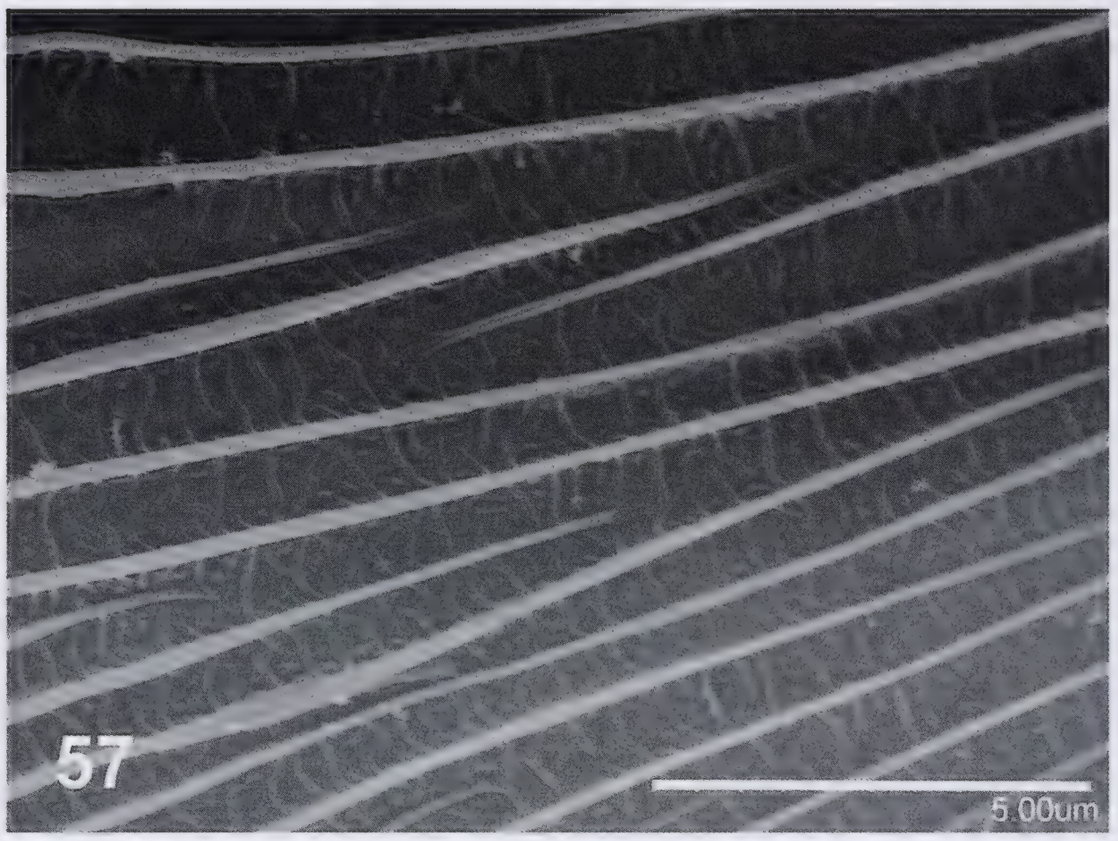
Body: Body length 4.7 mm (♀ holotype), 3.2 and 4.5 mm (♂1 and ♂2 paratypes). Epicuticle smooth when examined under optical microscope, thin reticular under high magnification (SEM, up to 1000x) (Fig. 70); body with thin, medium-sized, barbed clothing setae.

Head: Antennae length similar to body length (antennae length : body lenght ratio = 0.98 : 1), with 38 antennomeres. Bacilliform sensillum of third antennomere in a ventral position, between macrosetae *d* and *e,* 18 µm in length. Medial antennomeres elongated and 1.7 times longer than wide; apical antennomere 1.5 times longer than wide. Twelve to fourteen thin gouge sensilla (28 µm) in a single distal whorl on each medial and distal antennomere, plus one long bacilliform sensillum (13 µm) in same whorl (Figs 63-65). Cupuliform organ occupying less than 1/3 of total length of last antennomere, with numerous complex olfactory chemoreceptors with a centric column surrounded by radial folds; entire surface covered with a polygonal net with pores (Fig. 62). Frontal process with double protrusion above several tubercular setae (Figs 67-68). The three macrosetae along each side of line of insertion of antennomere and *x* setae with 4-8 thin barbs; length ratios of *a/i/p/x* in holotype being 39/45/38/56 (Fig. 68). Head carrying three pairs of moderately long, smooth macrosetae in *asl, psm, psl* position on dorsal side. Suboval labial palps, each with a bacilliform latero-external sensillum near two gard setae, with twelve normal setae in anterior portion and with up to 125 neuroglandular setae in medial and posterior position.

Thorax: Pronotum with 1+1 *ma*, 4+4-5+5 *la*, 2+2 $lp_{2,3}$ macrosetae; mesonotum with 1+1 *ma*, 1+1 *la*, 3+3 lp_{1-3}; metanotum with 1+1 *ma*, 3+3 lp_{1-3}; long barbed notal macrosetae with barbs in distal two-thirds; marginal setae longer than clothing setae, with thin distal barbs (Figs 66, 69-70). Metathoracic legs reaching tenth abdominal segment; without ventral macrosetae and







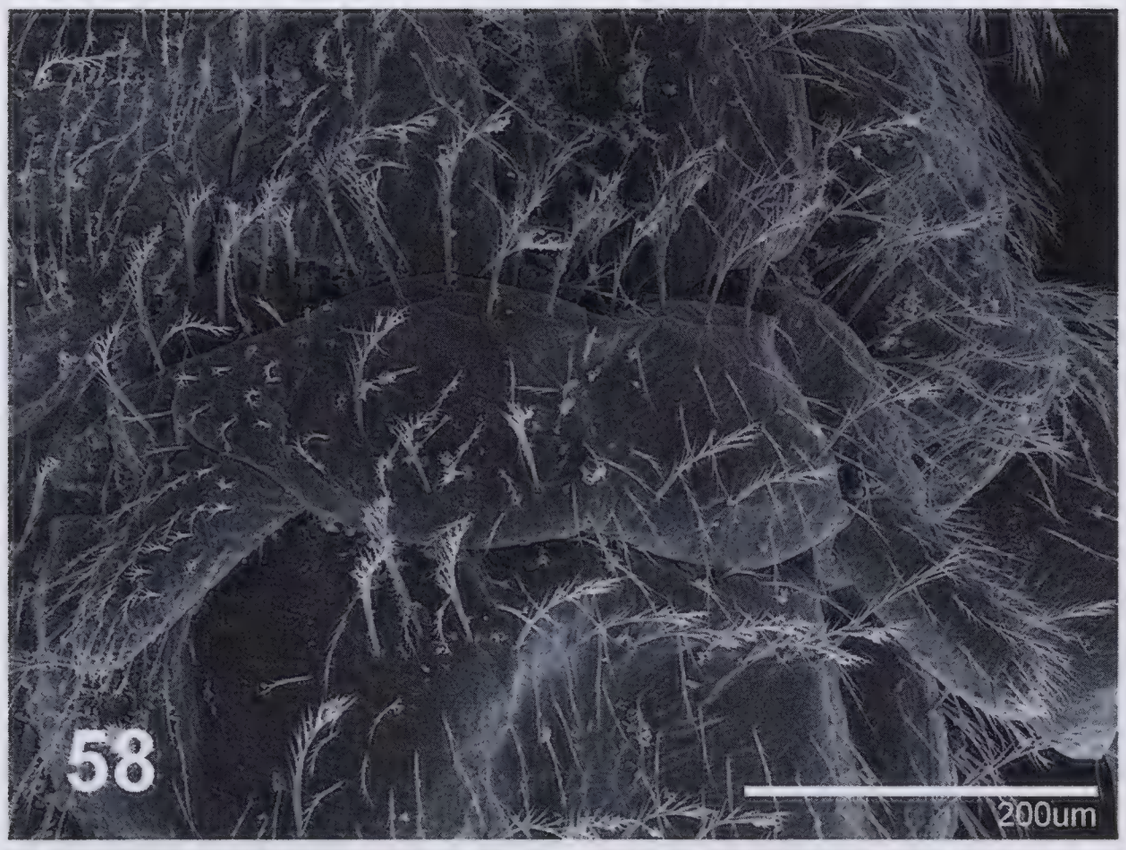
Figs 54-57. *Plusiocampa (Stygiocampa) christiani* Condé & Bareth, 1996. (54) Pretarsus of metathoracic leg, dorsal view. (55) Pretarsus of metathoracic leg, lateral view. (56) Joint between tarsus and tibia with the calcars (*cs*). (57) Detail of lateral ventral side of anterior claw of a metathoracic leg.

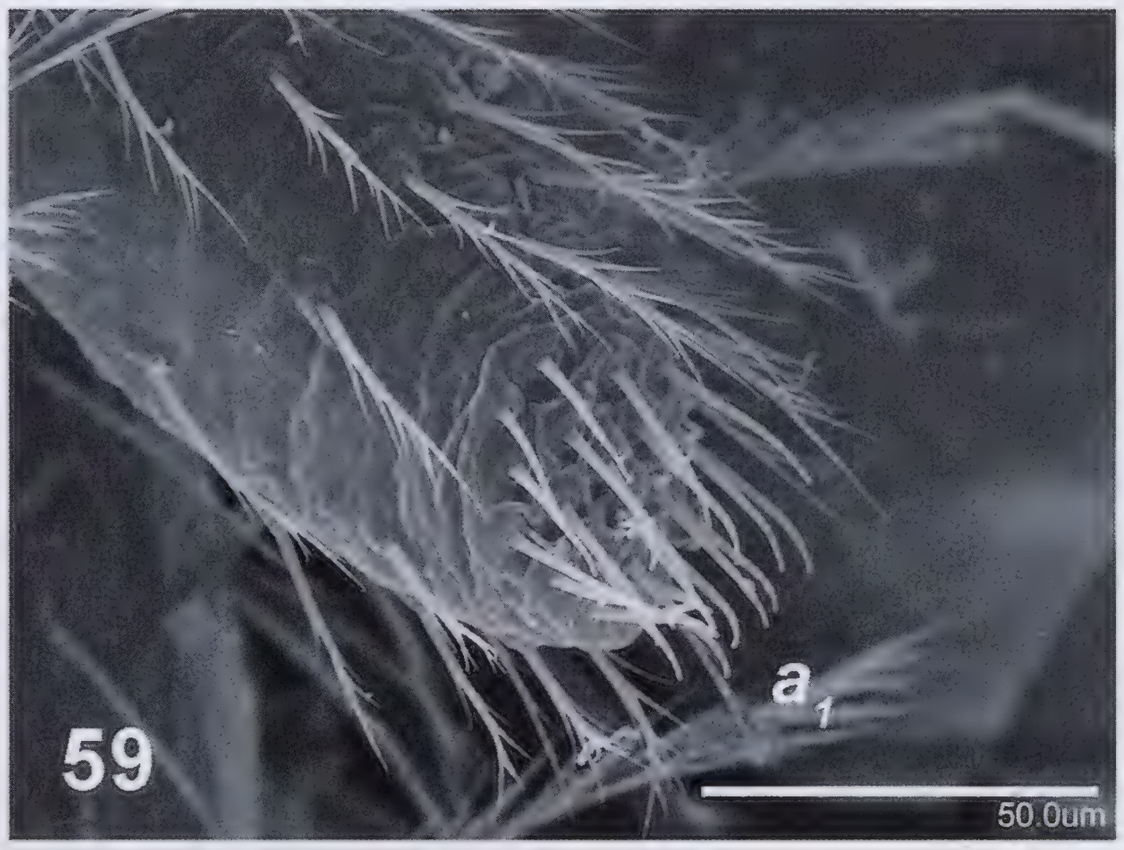
tibial macroseta; calcars with numerous long thin barbs in a few rows; tarsus with two ventral rows of larger, longer and more densely barbed setae than clothing setae, with numerous setiform sensilla among clothing setae (Fig. 73) and with two dorsal and two ventral subapical barbed setae; claws unequal (posterior claw 1.3 times longer than anterior claw), with large lateral crests and smooth setiform lateral processes or with a couple of barbs; posterior claw with large backward overhang; claws almost smooth on dorsal side, ventral side noticeably ridged and covered with micro-granular surface (Figs 71-72).

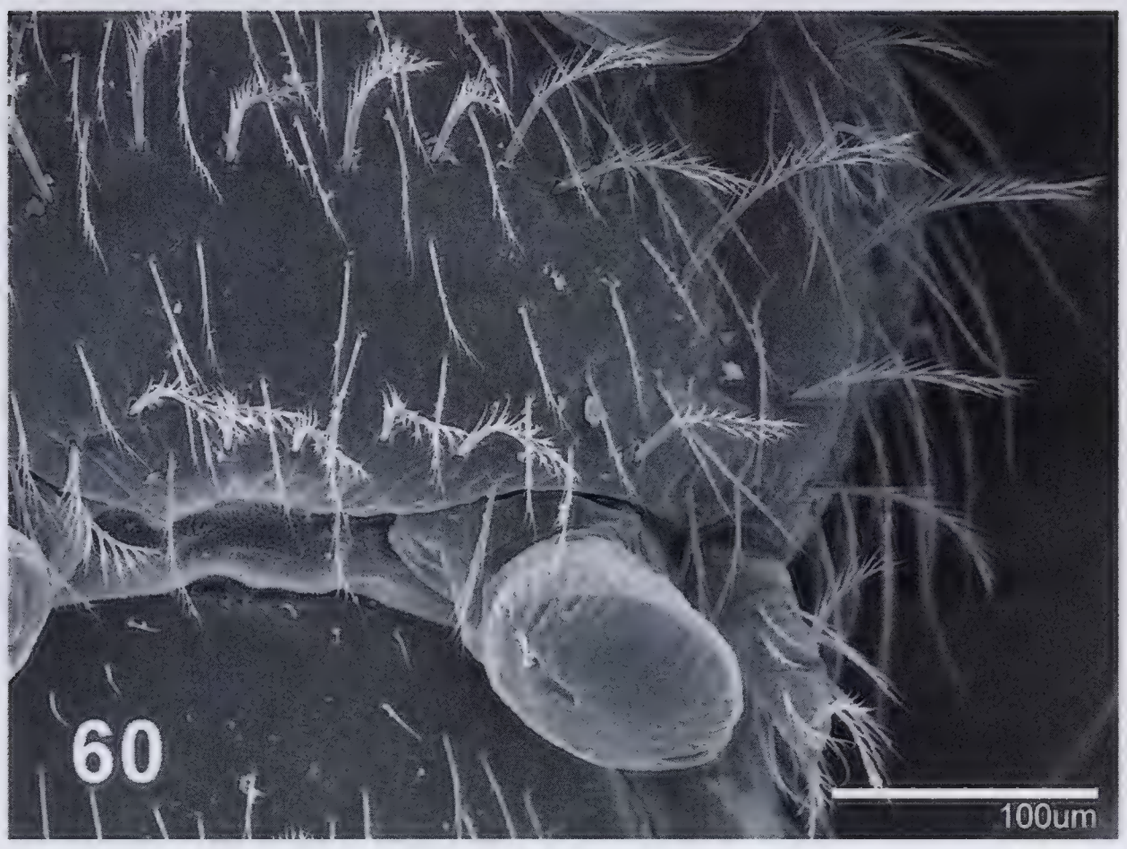
Abdomen: Urotergite I with 1+0 (0+0) $post_1$ macrosetae; urotergite II with 1+1 (0+1) $post_1$; urotergite III with 1+1 $post_1$; urotergite IV with 2+2 (2+1) $post_{1-2}$; urotergites V-VII with 1+1 *la*, 4+4 $post_{1-4}$; urotergite VIII with 6+6 *post*; abdominal segment IX with 9+9 (8+9) *post*; all urotergal macrosetae long and barbed in distal three-fourths; urosternite I with 7+7 macrosetae; urosternites II-VII with 6+6; urosternite VIII with 2+2; urosternal macrosetae with long medial and distal barbs (Fig. 75). Apical seta with a basal double tooth and two or three long thin barbs; subapical seta completely covered by short barbs; medio-ventral setae with four or six long thin barbs (Fig. 74). Eversible vesicles large, with proximal and distal areas of different microtexture (Fig. 76). Best preserved cercus broken; each primary article bearing from two to eight irregular whorls of long barbed macrosetae, one distal whorl of long smooth setae, and one apical whorl of short thin setae with tiny distal barbs.

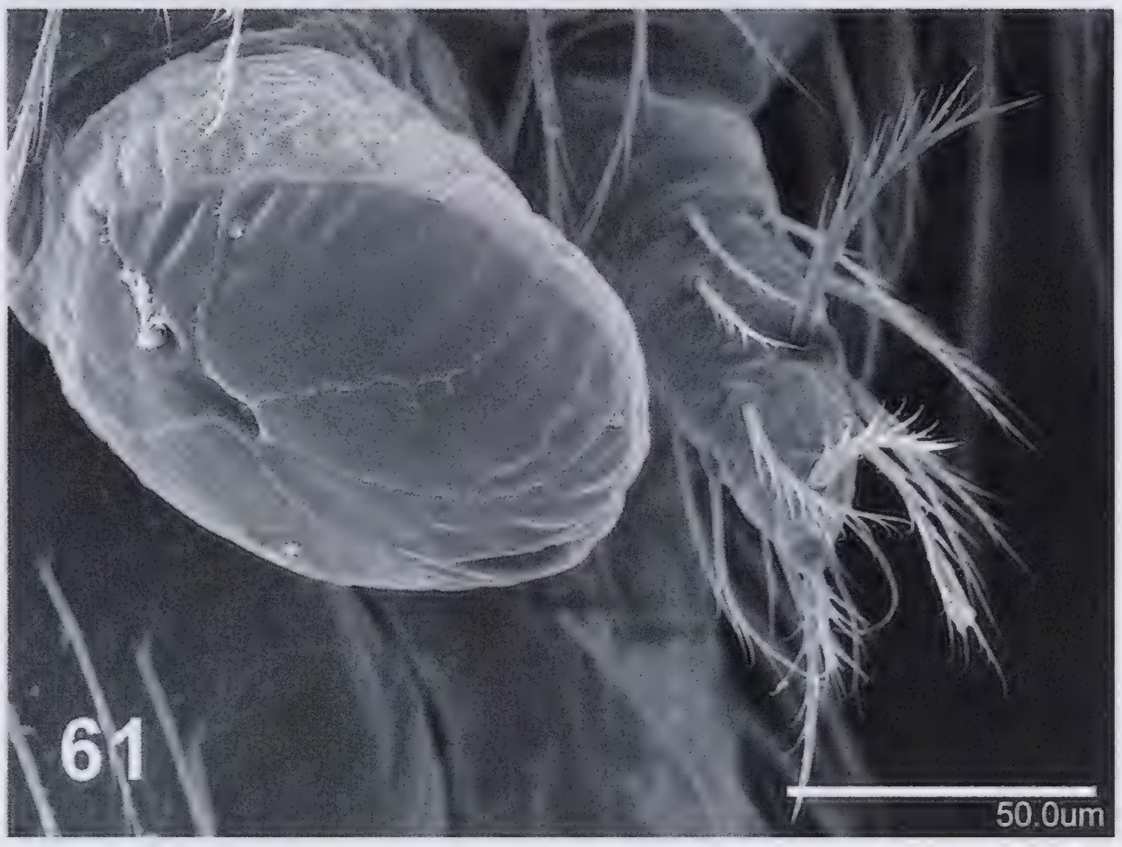
Secondary sex characters: First urosternite of males with subcylindrical appendages, each bearing 10 and 8 glandular a_1 setae; posterior border of urosternite I with 90 and 4 glandular g_1 setae in two males studied: one adult male (♂1 paratype) and one young male (♂2 paratype); female holotype with subcylindrical appendages, each carrying up to 16 glandular a_1 setae.

Taxonomic affinities: *Plusiocampa (Stygiocampa) dulcici* Sendra & Rađa, sp. nov. is closely related to









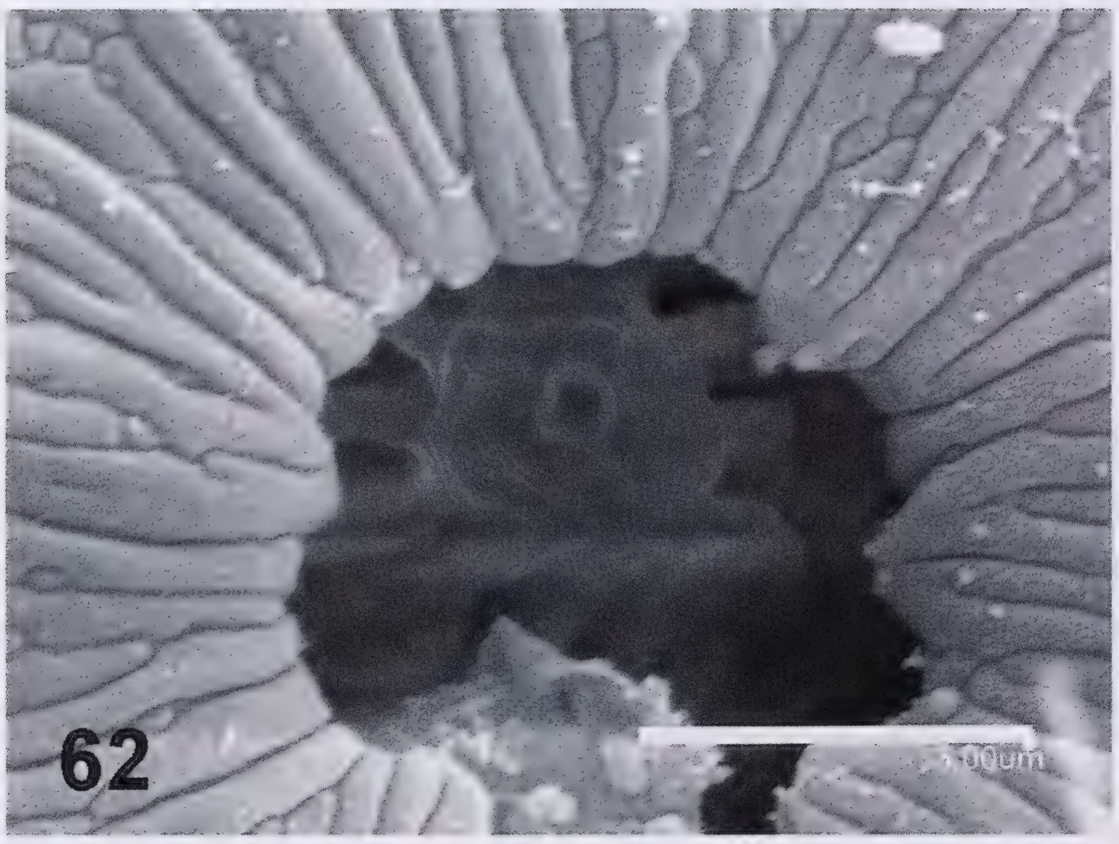
Figs 58-61. *Plusiocampa (Stygiocampa) christiani* Condé & Bareth, 1996. (58) First abdominal segment of a female, ventral view. (59) Distal portion of left appendage of first urosternite of a female. (60) Medial and lateral left side of fourth abdominal segment, ventral view. (61) Eversible vesicles and stylus of left side of fourth urosternite.

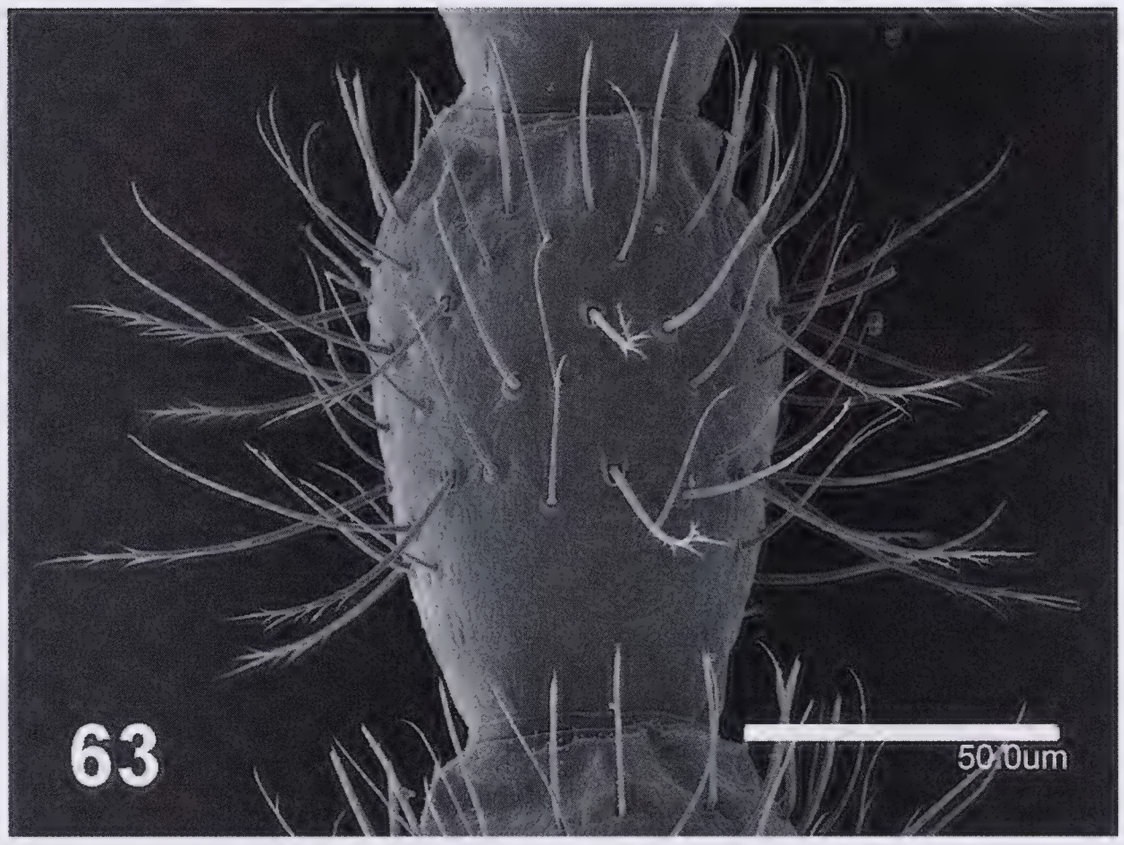
Pluciocampa (Stygiocampa) denisi Condé, 1947 due to similarities in the distribution pattern of urotergal and urosternal macrosetae, both with 1+1 lateral anterior and 4+4 posterior macrosetae on the sixth and seventh urotergites, and 7+7 and 2+2 urosternal macrosetae on the first and seventh urosternites (Condé, 1947). A remarkable distinction from *P. (S.) denisi* is the number of lateral posterior macrosetae on the mesonotum and metanotum: *P. (S.) dulcici* sp. nov. has 3+3 such macrosetae on the mesonotum and metanotum, whereas *P. (S.) denisi* has 1+1 lateral posterior macrosetae on the mesonotum but none the metanotum. Other taxonomical features that differ between *P. (S.) dulcici* sp. nov. and *P. (S.) denisi* are the presence of macrosetae on the first to the third urotergites in *P. (S.) dulcici* sp. nov. *vs.* their absence in *P. (S.) denisi,* and the 6+6 macrosetae on the second to the seventh urosternite in *P. (S.) dulcici* sp. nov. *vs.* 5+5 in *P. (S.) denisi*.

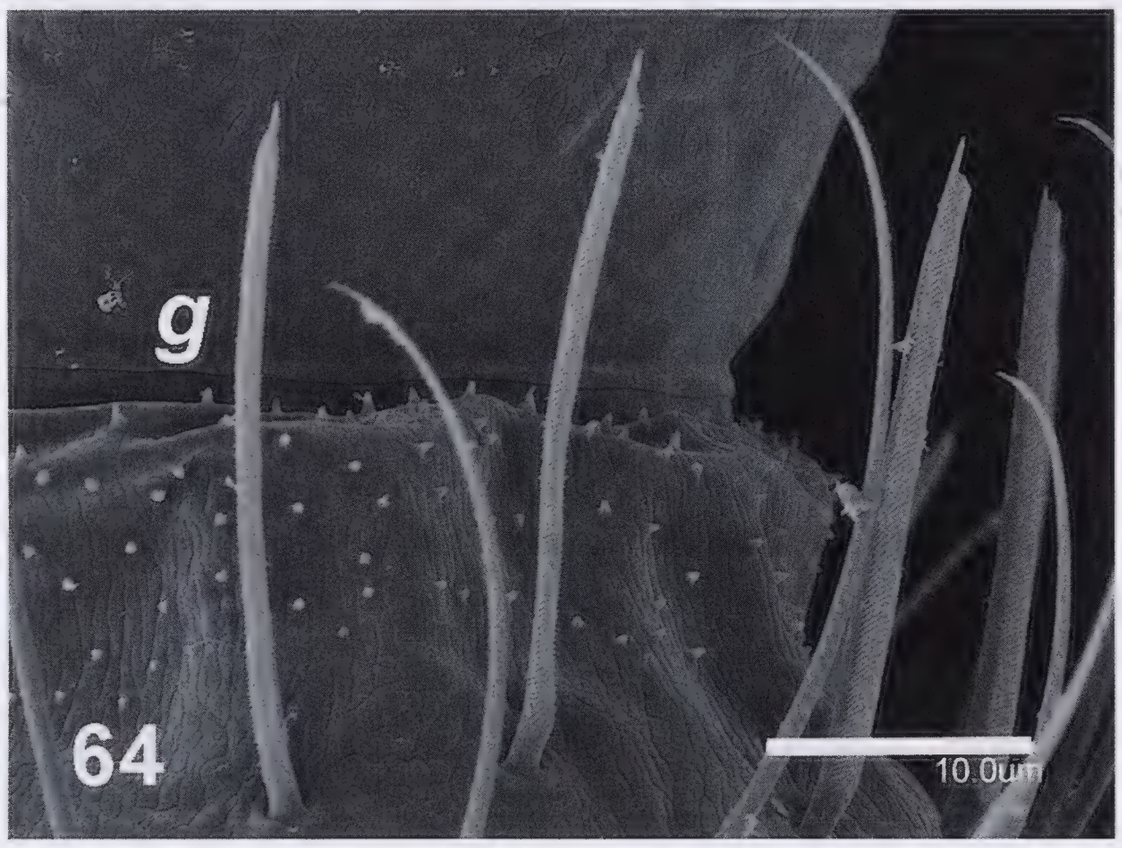
Type locality: The Golubinka pod Krajevcem Pit is about 25 m deep and about 30 m long, with two entrances (Fig. 43) at 233 m a.s.l. through which the daylight reaches the bottom of the pit, allowing a Mediterranean shrub and moss community to grow. The final chamber is large, 20 x 24 m, with a mean annual temperature of around 10°C. Several specimens of the new species were collected under small stones at 22 m depth (Fig. 42). During the wet season the cave is very humid. Golubinka pod Kraljevcem is renowned for being the habitat of several cave species, i.e., *Troglaegopis mosorensis* (Kuščer, 1933) (Mollusca: Gastropoda), *Neotrechus dalmatinus* (L. Miller, 1861) (Insecta: Coleoptera), *Psychoda* sp. (Insecta: Diptera), *Solentanodesmus insularis* Antić & Reip in Antić *et al.,* 2014 (Myriapoda: Diplopoda).

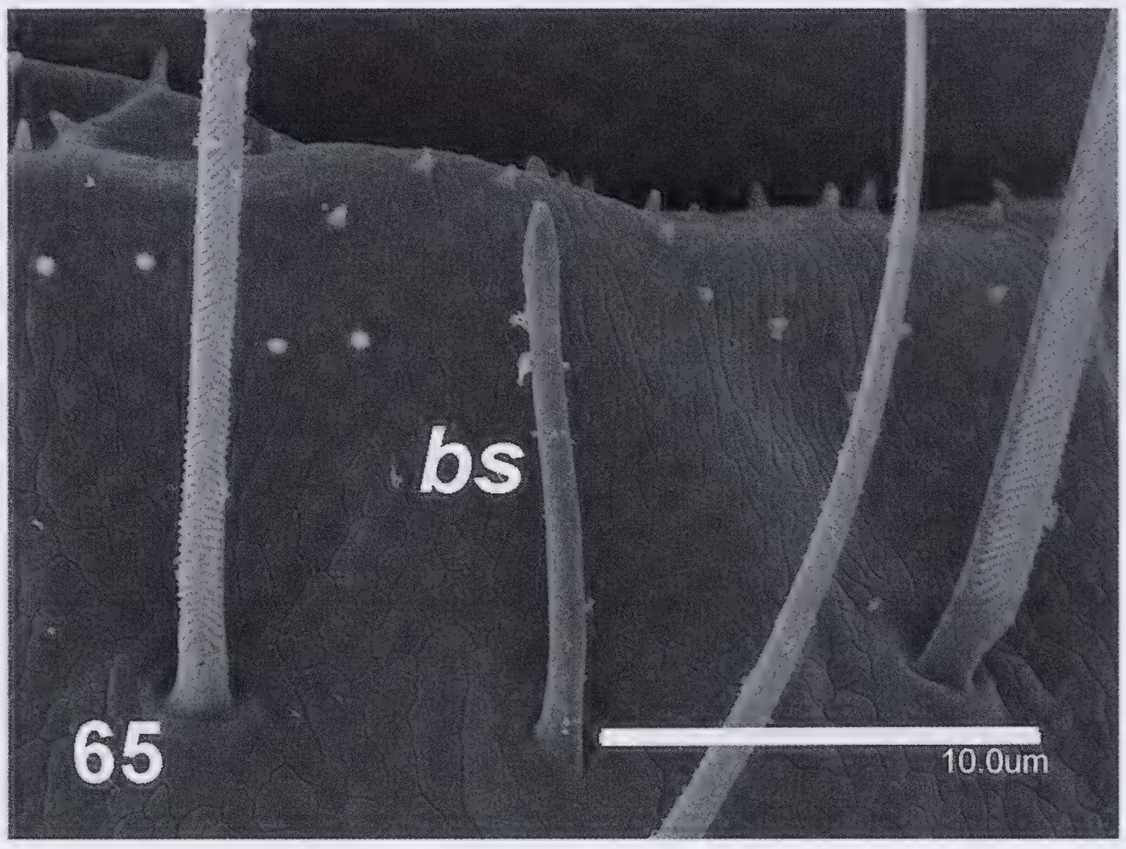
Plusiocampa (Stygiocampa) remyi Condé, 1947

Material studied: Coll. AS; one male; Montenegro, Cetinjska Cave, Cetinje; 24th June 2018; leg. D. Antić. – Coll. AS; one male; Montenegro, Velika (Njegoševa)









Figs 62-65. *Plusiocampa (Stygiocampa) dulcici* Sendra & Rađa, sp. nov. (62) Hole of cupuliform organ of last antennomere. (63) Medial antennomeres. (64) Detail of lateral anterior side of a medial antennomere with some gouge sensilla (g). (65) Detail of lateral anterior side of a medial antennomere with one bacilliform sensillum (*bs*).

Cave, Njeguši, Mt Lovćen, Cetinje; 24th June 2018; leg. D. Antić. – Coll. AS; one female; Montenegro, Vojvode Dakovića Cave, Grahovo, Nikšić; 28th July 2018; leg. S. Ćurčić, N. Vesović. – Coll. AS; one male and two females; Bosnia & Herzegovina, Golubinka, Dabarsko Polje, Berkovići/Bileća; 18th June 2003; leg. S. Ognjenović. – Coll. AS; one male; Montenegro, Arapova Cave, Gornja Grabovica, Mt Durmitor; 29th July1993; leg. D. Pavićević. – Coll. AS; three males and three females; Montenegro, Vojvode Dakovića Cave, Grahovo, Nikšić; 28th July to 27th October 2018; leg. S. Ćurčić, N. Vesović, M. Kuraica. – Coll. AS; one male; Montenegro, Izeta Cave, Knežlaz, Kameno more, Kotor; 28th July to 27th October 2018; leg. S. Ćurčić, N. Vesović, M. Kuraica. – Coll. AS; three females; Montenegro, Lipska Cave, Lipa, Cetinje; 29th July to 28th October 2018; leg. N. Vesović. – Coll. AS; one male; Montenegro, Bijela Cave, Gornji Kazanci, near Nikšić; 17th November 2019; leg. D. Antić.

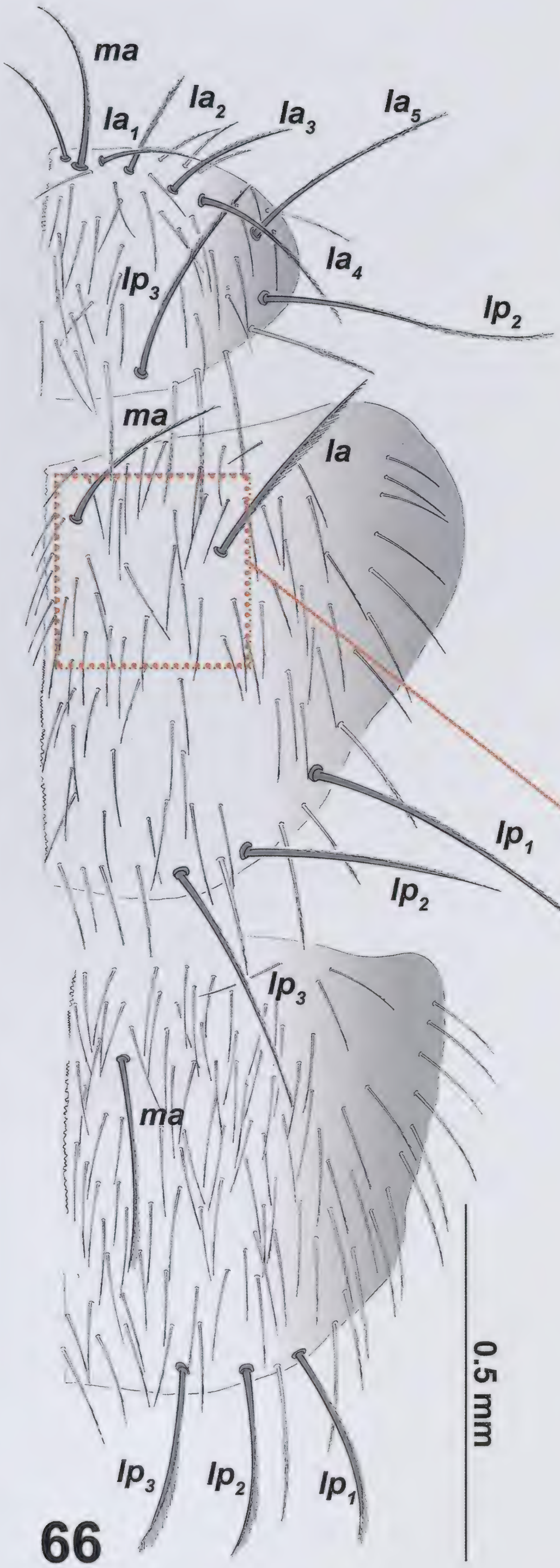
Biogeographical note: These localities extend the known distribution range of the species.

Subgenus *Venetocampa* Bareth & Condé, 1984

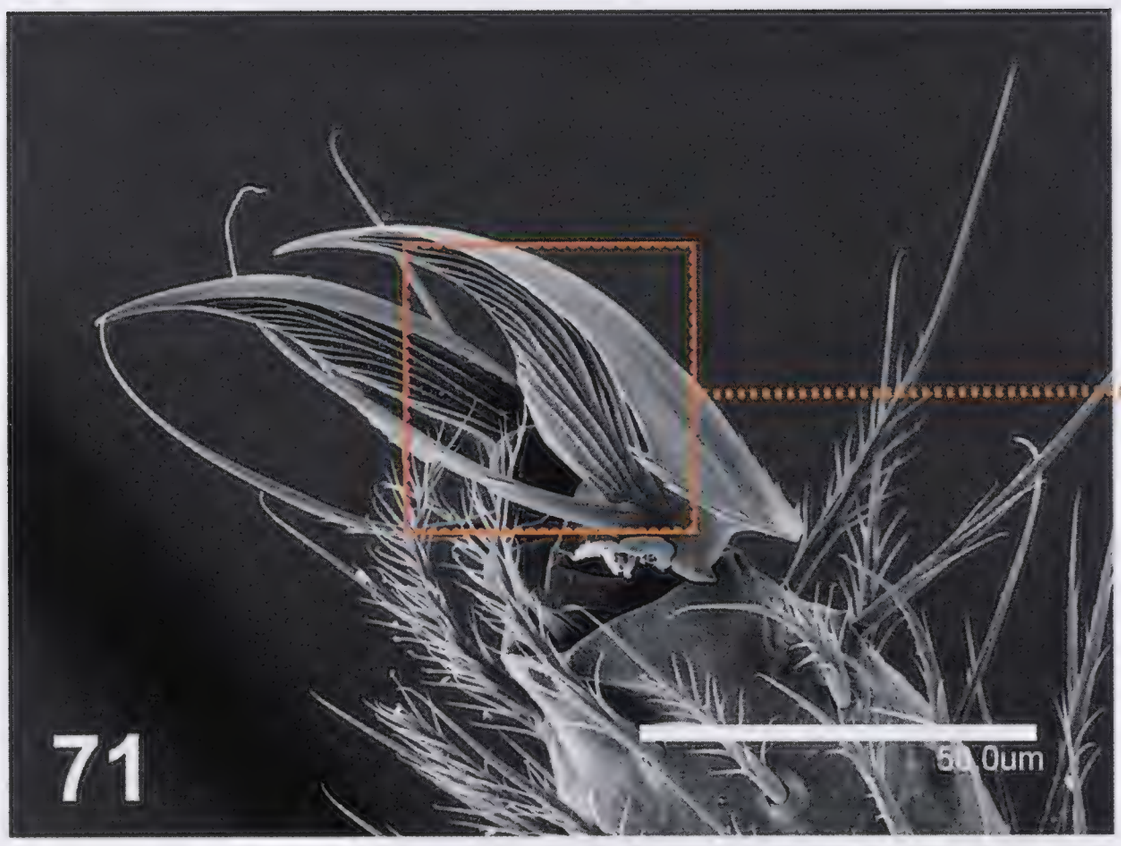
Plusiocampa (Venetocampa) pirnati Sendra & Borko, sp. nov.

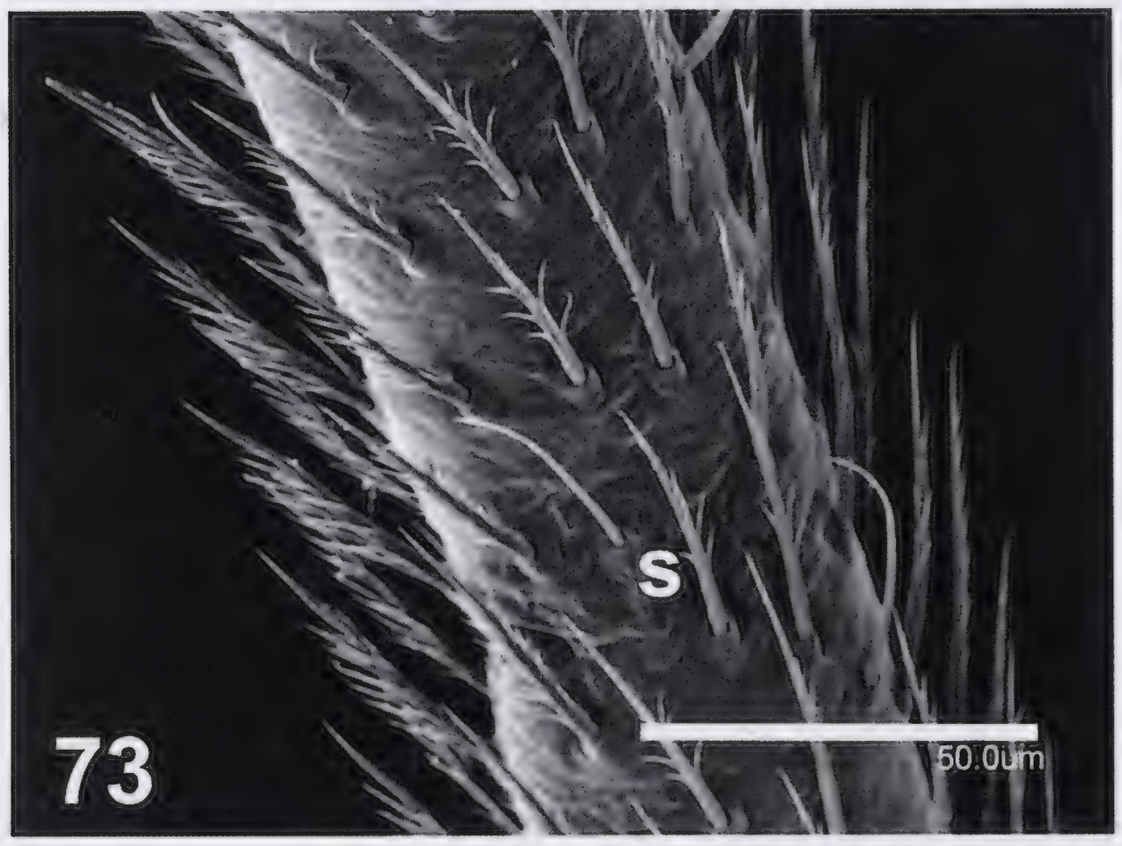
Figs 77-97, Table 4

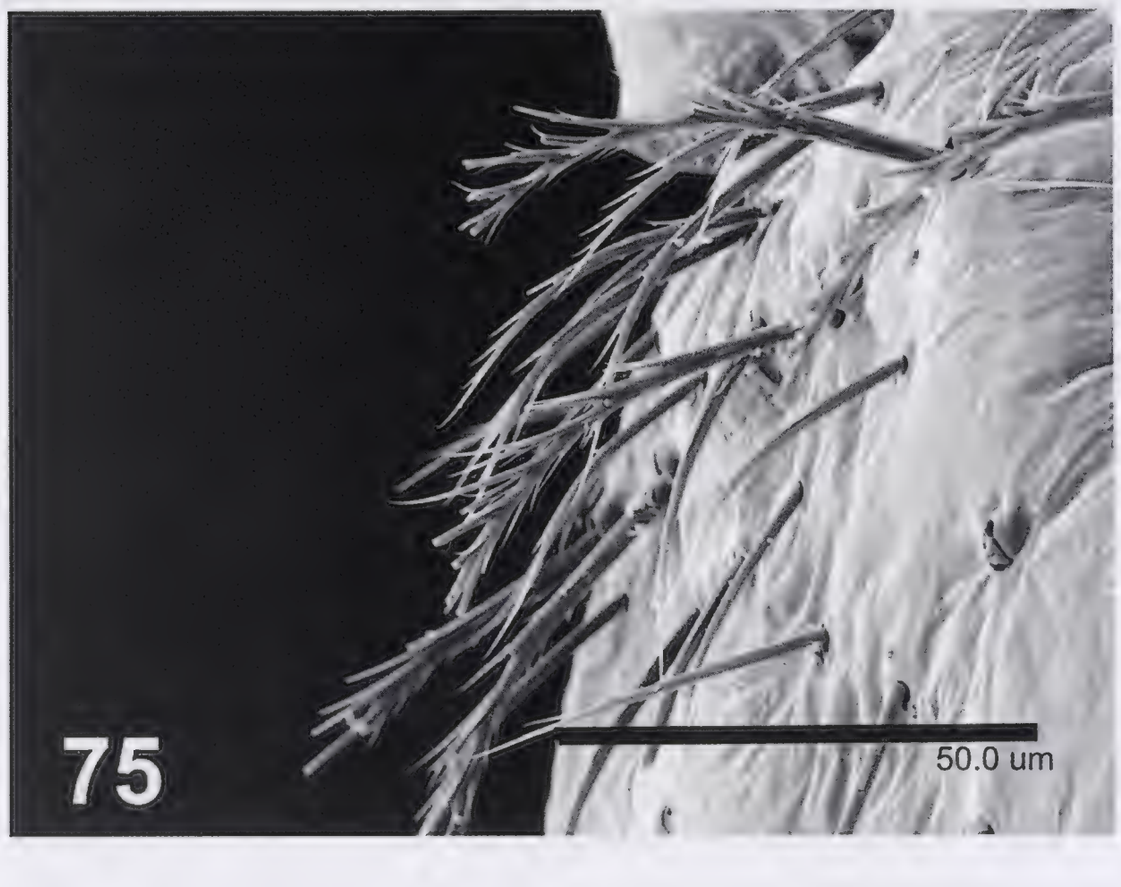
Type material: PSML; male holotype; Slovenia, cave P4, Kanin, Bovec; 3rd August 2018; leg. Š. Borko. – PSML; one female paratype (labelled ♀1 paratype); same cave, data, and collector. – MHNG; one male and two female paratypes (labelled ♀2 paratype, ♀3 paratype, ♂5 paratype); same cave, data, and collector. – Coll. AS; four male, one female and one juvenile paratypes (labelled ♀4 paratype, ♂2 paratype, ♂3 paratype, ♂4 paratype, ♂6 paratype and J1 paratype); same cave, data, and collector.



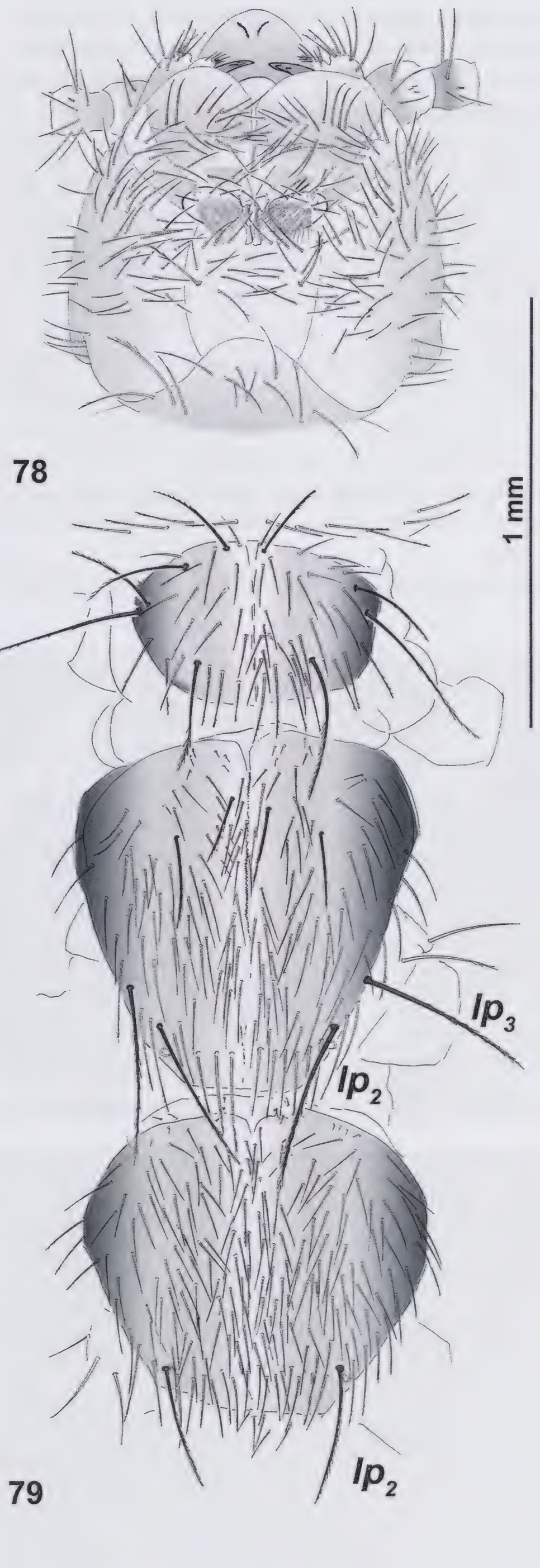
Figs 66-70. *Plusiocampa (Stygiocampa) dulcici* Sendra & Rađa, sp. nov. (66) Pronotum, mesonotum and metanotum of holotype. (67) Detail of anterior portion of frontal process, dorsal view. (68) Frontal process on head, dorsal view. (69) Detail of mesonotum surface with partial view of medial anterior and lateral anterior macrosetae. (70) Detail of insertion of medial anterior macrosetae of mesonotum and partial view of clothing setae.







Figs 71-76. *Plusiocampa (Stygiocampa) dulcici* Sendra & Rađa, sp. nov. (71) Pretasus, lateral view. (72) Detail of posterior claw of pretarsus with anterior claw in the background. (73) Lateral view of tarsus with setiform sensilla (s). (74) Stylus of fourth urosternite. (75) Urosternal macrosetae on first urosternite. (76) Eversible vesicle of fifth urosternite.



Figs 77-79. *Plusiocampa (Venetocampa) pirnati* Sendra & Borko, sp. nov. (77) Habitus, dorsal view. (78) Head, ventral view. (79) Pronotum, mesonotum and metanotum, dorsal view.

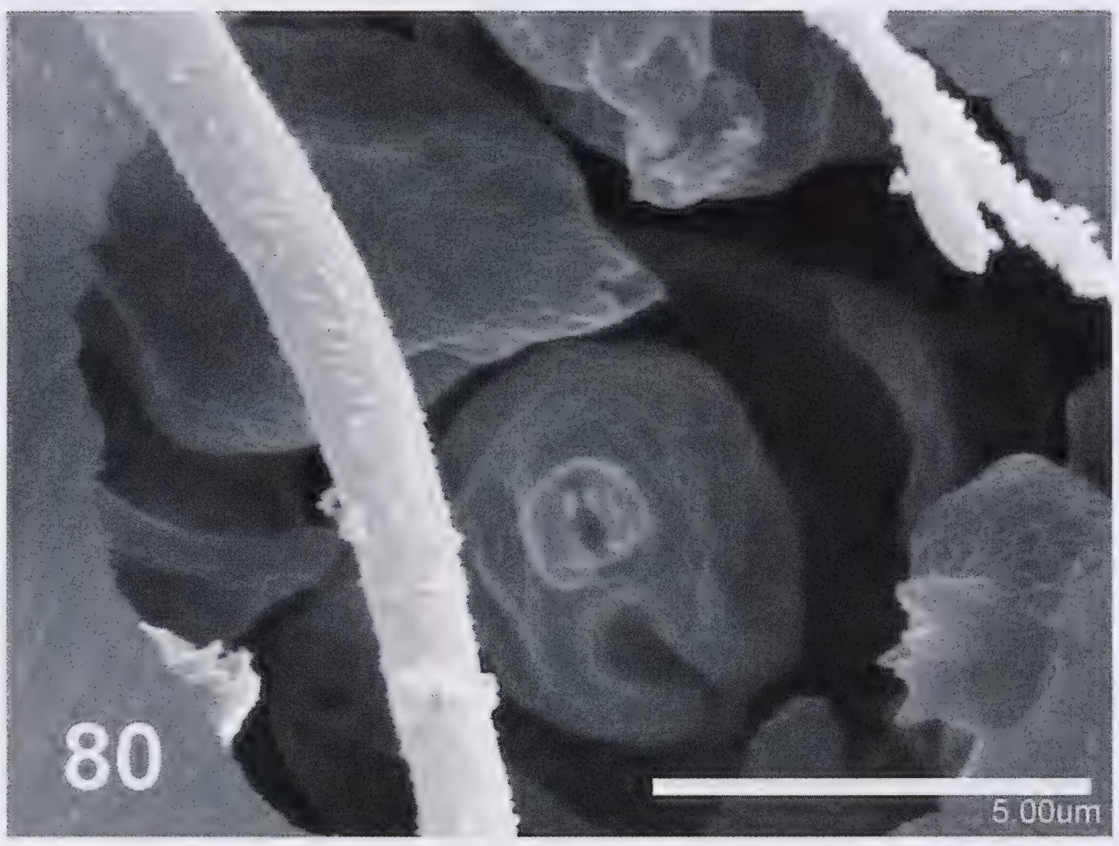
Other material studied: Coll. AS; five males and thirteen females; same cave, data, and collector as for type material mounted in Marc André II solution. – Coll. AS; six specimens of unknown sex; same cave, data, and collector; mounted on an aluminium stub and coated with palladium-gold.

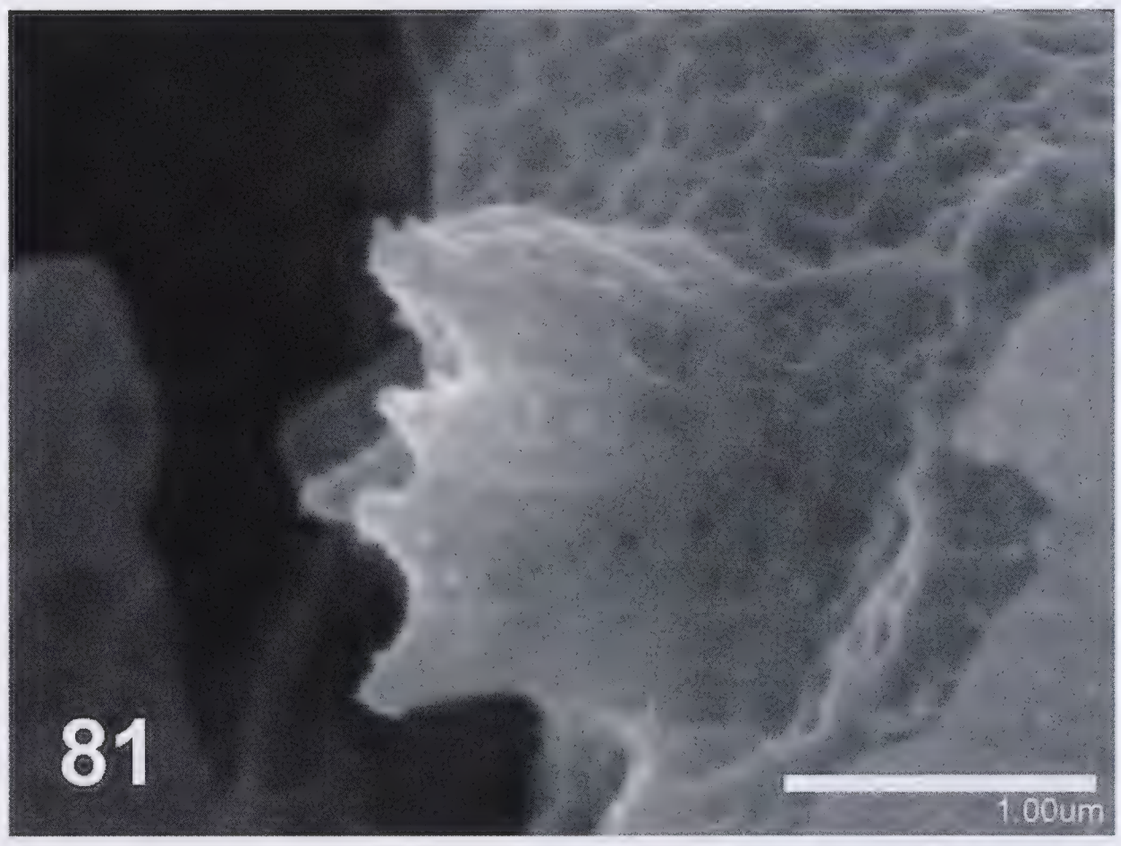
Etymology: The new species is named after Joško Pirnat, a caver who significantly contributed to the speleological exploration of the area and without whom these remote sites could not have been explored. Name in the genitive case.

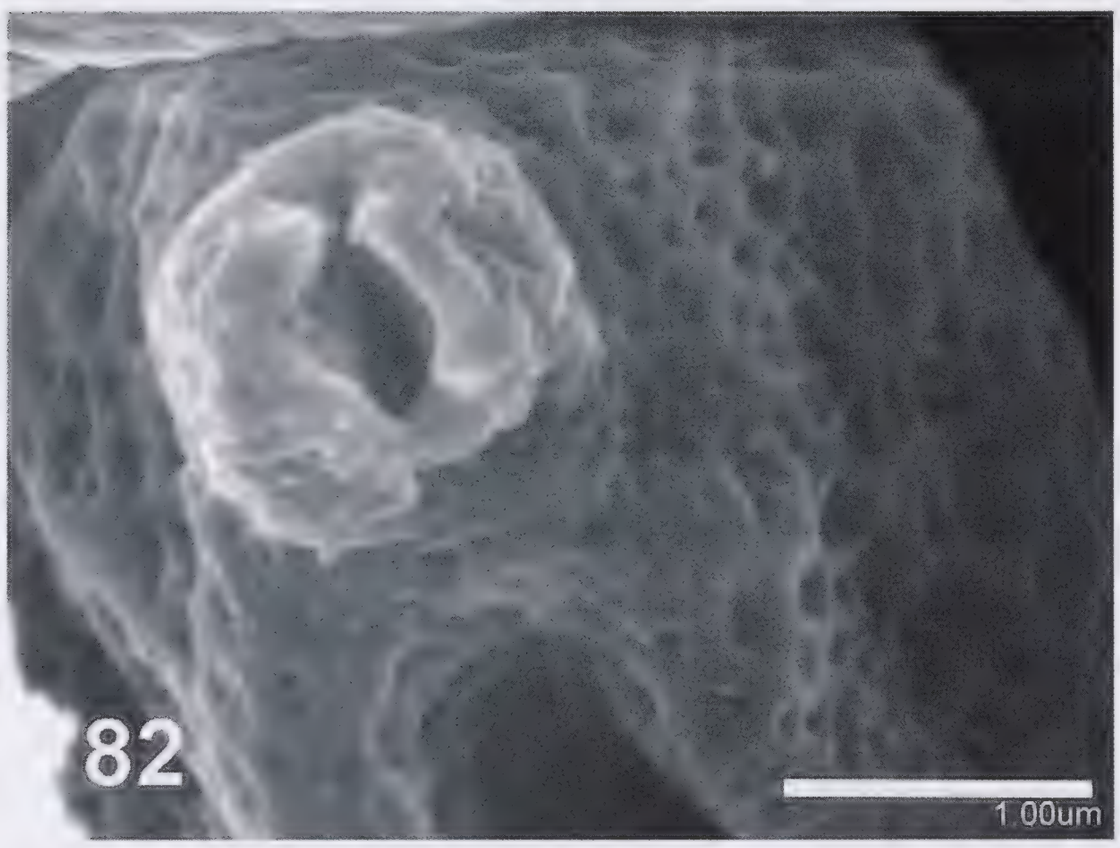
Description:

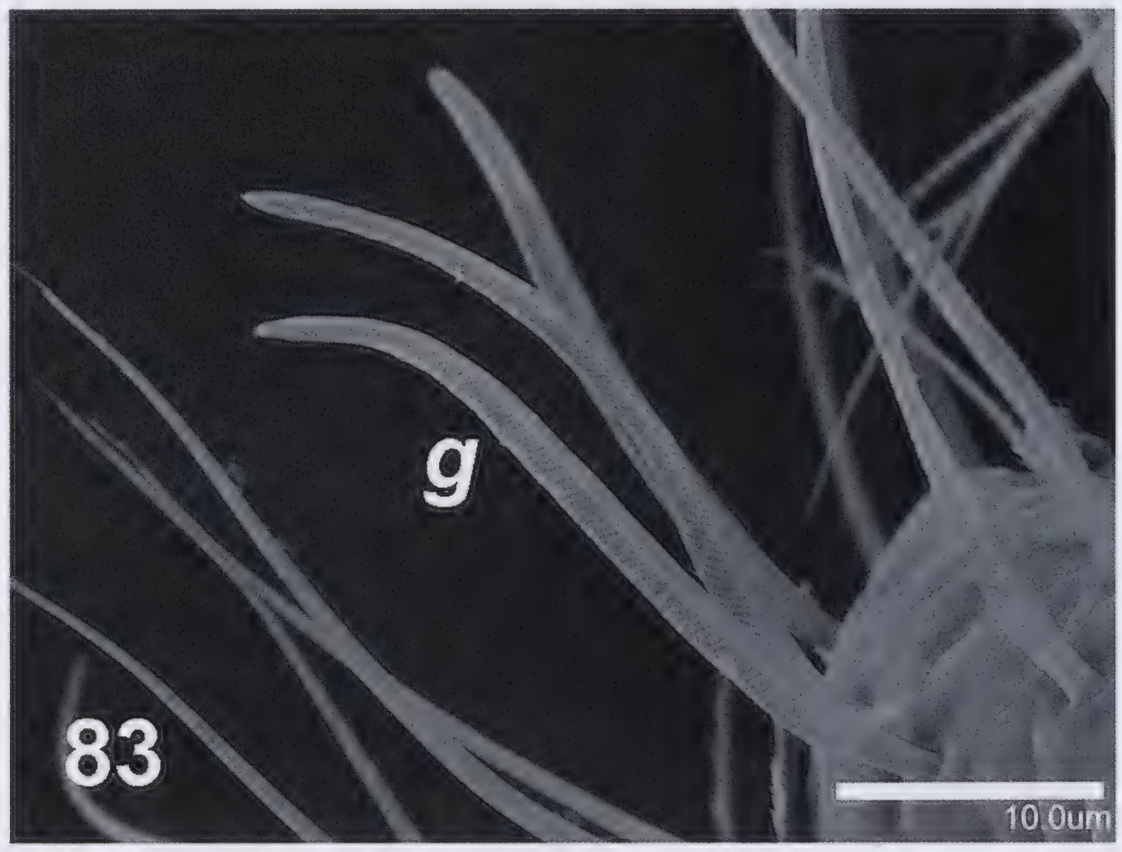
Body: Body length 4.3-4.9 mm (males), 4.1-5.6 mm (females) and 2.9 mm in one juvenile (in type series) (Fig. 77). Epicuticle smooth under optical microscope, weakly reticulated under high magnification (SEM, up to 1000x) (Figs 84-85); body covered with numerous thin, medium-sized clothing setae bearing two to five thin distal barbs.

Head: Antennae lengths ranging from 109% of body length in small specimens to 86% of body length in larger specimens, with 34-36 antennomeres (Table 4). Bacilliform sensillum of third antennomere in a ventral position, between macrosetae *d* and *e,* 13 µm in length. Medial antennomeres slightly elongated and 1.4 times longer than wide; apical antennomere 2.5 times longer than wide. Ten to fifteen thin and long gouge sensilla (30-38 µm long) in a single distal whorl on each medial and distal antennomere (Fig. 83); two conical sensilla (8 µm) in the same whorl. Cupuliform organ occupying less than 1/4 of total length of last antennomere, with eight to ten spheroidal olfactory chemoreceptors with a centric column surrounded by a concentric fold; entire surface covered with a polygonal net with pores (Figs 80-82). Non-protruding frontal process with three smooth, slightly tubercular anterior macrosetae and without tubercular setae. The three macrosetae along each side of line of insertion of antennomere and *x* setae with 2-4 long thin barbs; length ratios of *a/i/p/x* in holotype being 32/39/33/38. A pair of slightly longer smooth macrosetae on dorsal side of head in *a psl* position. Labial palps









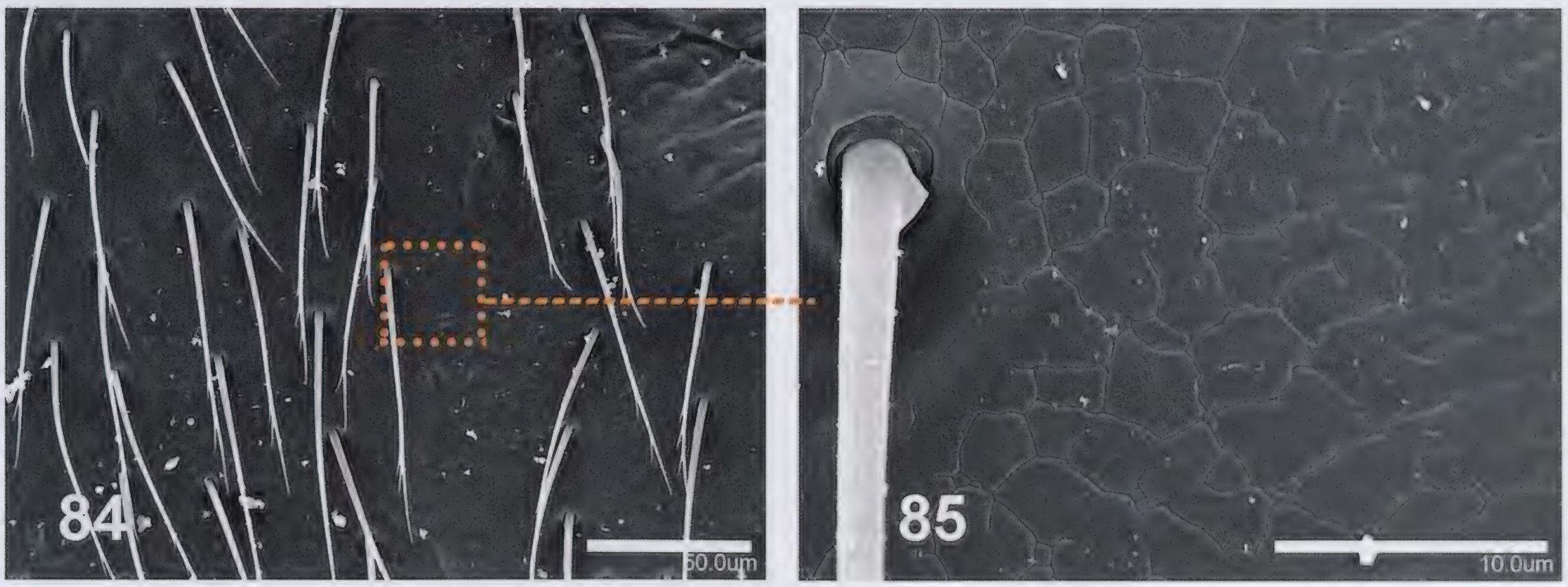
Figs 80-83. *Plusiocampa (Venetocampa) pirnati* Sendra & Borko, sp. nov. (80) Interior of cupuliform organ of last antennomere. (81-82) Different details of olfactory chemoreceptor of cupulifom organ. (83) Lateral distal portion of a medial antennomere with gouge sensilla (*g*).

suboval, each with a conical latero-external sensillum near two gard setae, with five normal setae in anterior portion, and with up to 62 neuroglandular setae in a medial and posterior position. Narrow submentum with two posterior macrosetae with 3-5 long, thin distal barbs and a smooth anterior row of setae (Fig. 78).

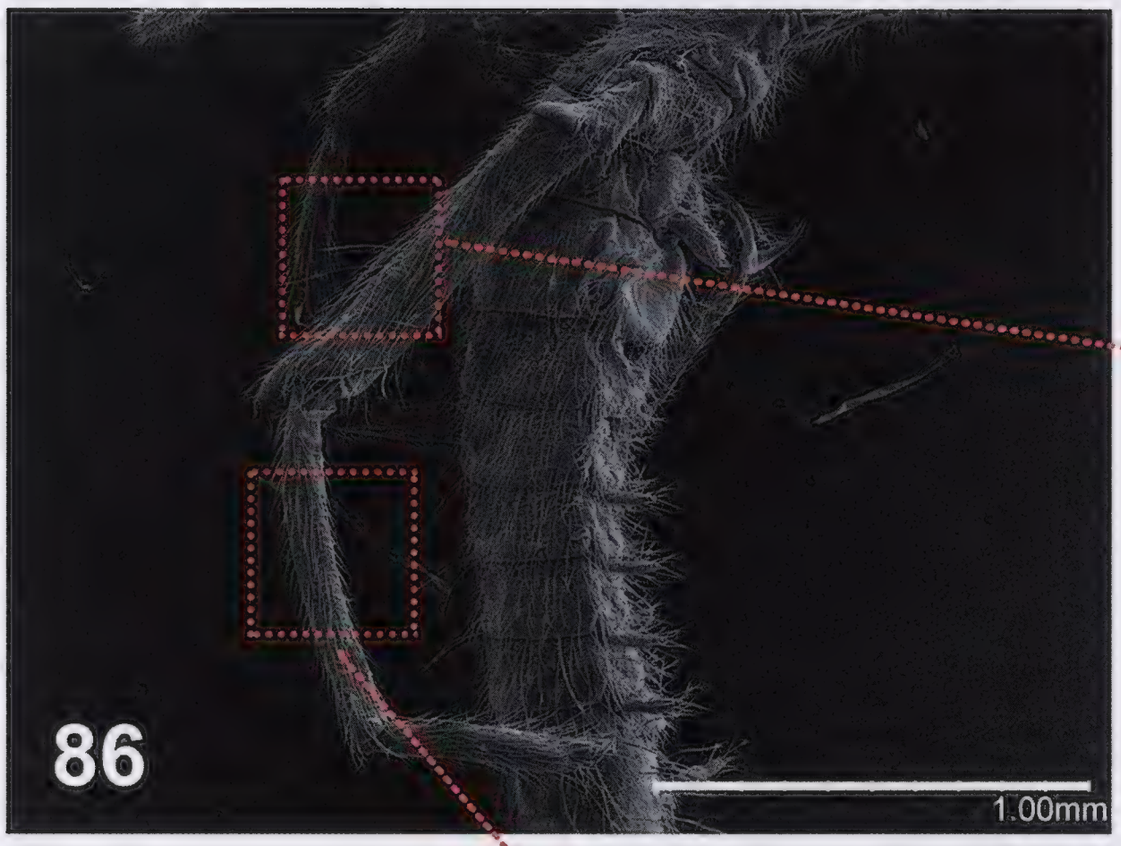
Thorax: Pronotum with 1+1 *ma*, 2+2 *la*, 2+2 $lp_{2,3}$ macrosetae; mesonotum with 1+1 s*ma*, 1+1 s*la* or 1+0 *sla* - 0+1 *la*, 2+2 $lp_{2,3}$; metanotum with 1+1 lp_2; long, thin, barbed notal macrosetae in distal two-thirds; marginal setae slightly longer than clothing setae, with a few thin distal barbs (Fig. 79). Metathoracic legs reaching beyond end of abdomen; femur and tibia being the longest articles with a similar length (Table 4). One dorsal femoral macroseta in distal half with thin barbs 0.20-0.25 mm in length, and with three slightly shorter barbed ventral macrosetae (Figs 86-87); two (rarely three) short metathoracic tibial macrosetae barbed in distal half (Fig. 88); calcars with long thin barbs in two rows on one side (Fig. 89); tarsus with two ventral rows of smooth setae slightly larger and longer than clothing setae; two dorsal and two ventral subapical smooth setae on tarsus; very unequal claws (posterior claw 1.5-1.6 longer than anterior claw), with large lateral crests and smooth setiform lateral processes; posterior claw with large backward overhang; claws almost smooth on dorsal side, ventral side with a micro-bacilliform to granular surface between noticeable crests; an intermediate small, thin irregular structure present between the claws (Figs 90-93).

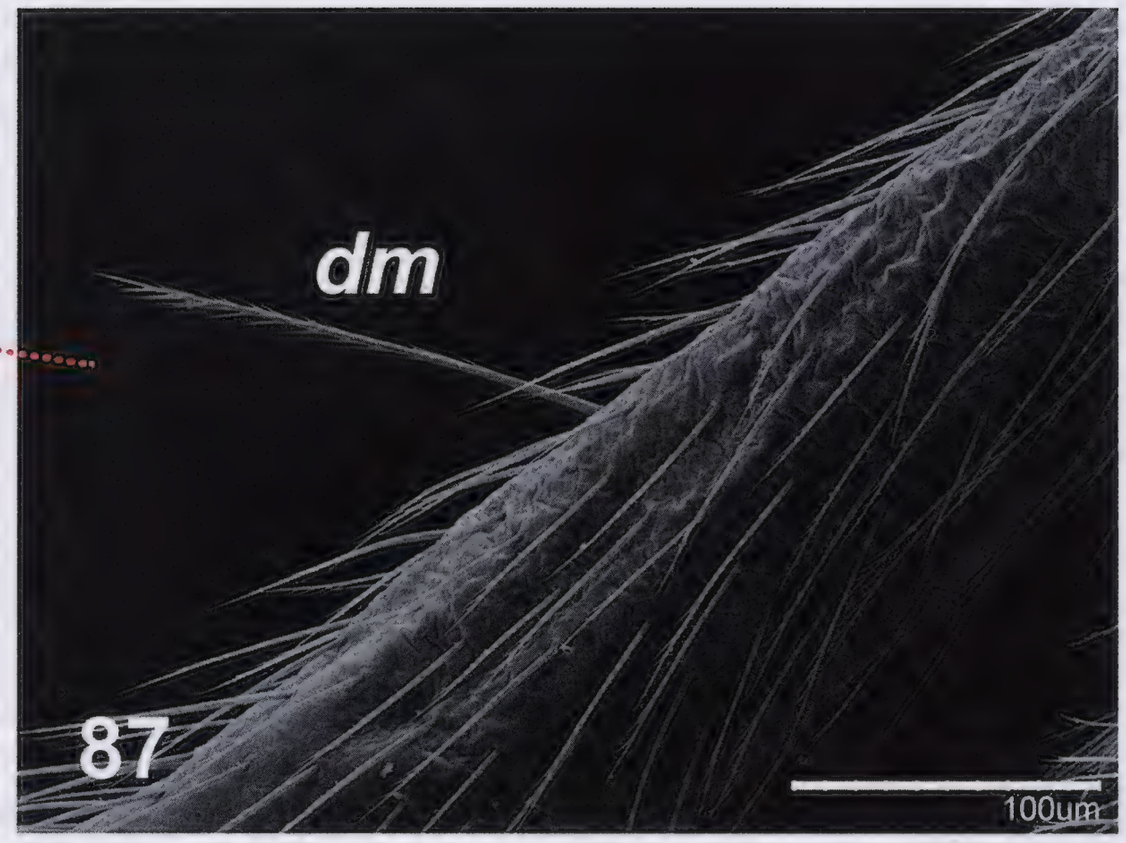
Table 4. *Plusiocampa (Venetocampa) pirnati* Sendra & Borko, sp. nov. Length (in mm) of body, antennae, femur, tibia and tarsus of metathoracic legs and of cerci.

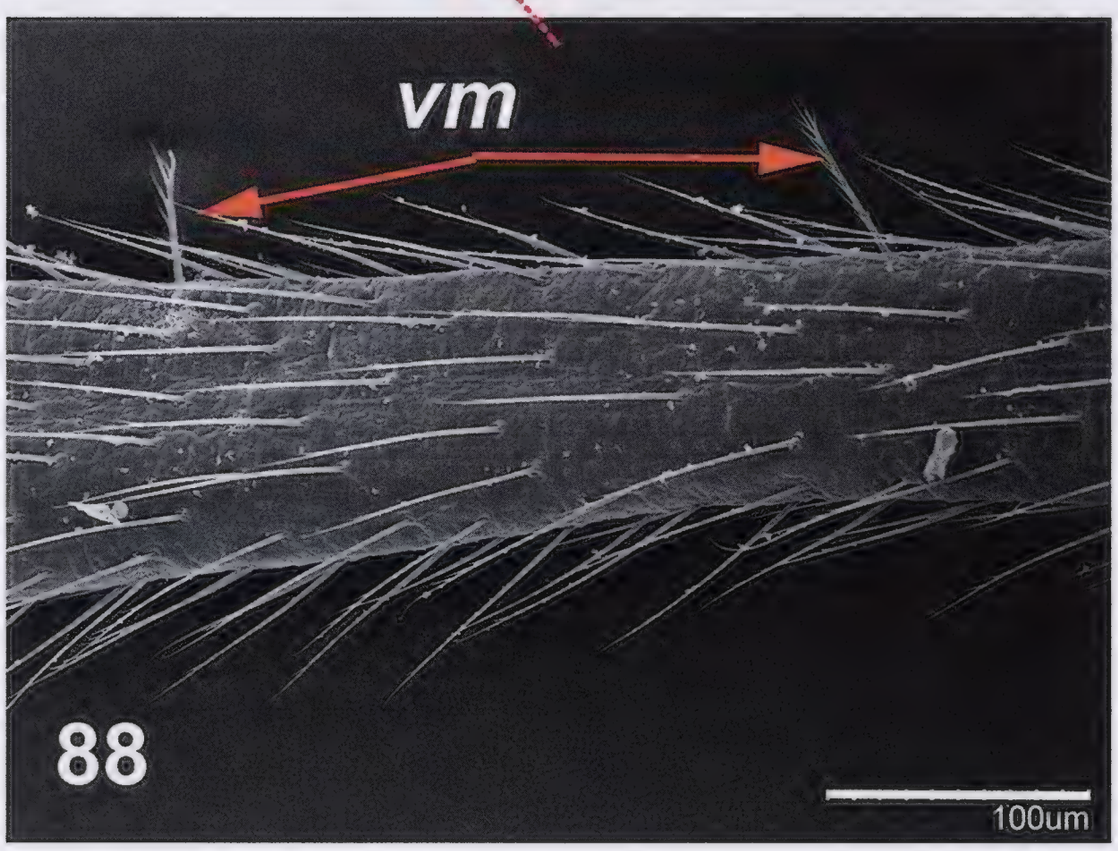
specimen	body	antennae	number of antennomeres	femur	tibia	tarsus	number of primary cercal articles	cercus
J1 paratype	2.9	3.0	35	0.55	0.56	0.54	-	-
♀4 paratype	4.1	4.4	36	0.90	0.81	0.70	-	-
♂4 paratype	4.3	4.7	35	1.05	0.95	0.70	-	-
♂5 paratype	4.4	4.3	34	0.81	0.90	0.65	9	4.6
♂3 paratype	4.5	4.1	35	1.00	0.95	0.73	-	-
♂2 paratype	4.7	4.6	35	0.91	1.05	0.75	-	-
♂1 holotype	4.8	4.6	35	0.92	0.91	0.73	8	4.7
♀2 paratype	4.8	4.6	35	0.97	1.02	0.80		
♂6 paratype	4.9	4.3	35	0.86	0.98	0.73		
♀3 paratype	5.1	-	-	0.97	1.02	0.73	9	4.6
♀1 paratype	5.6	4.8	36	1.01	1.11	0.76	11	6.2

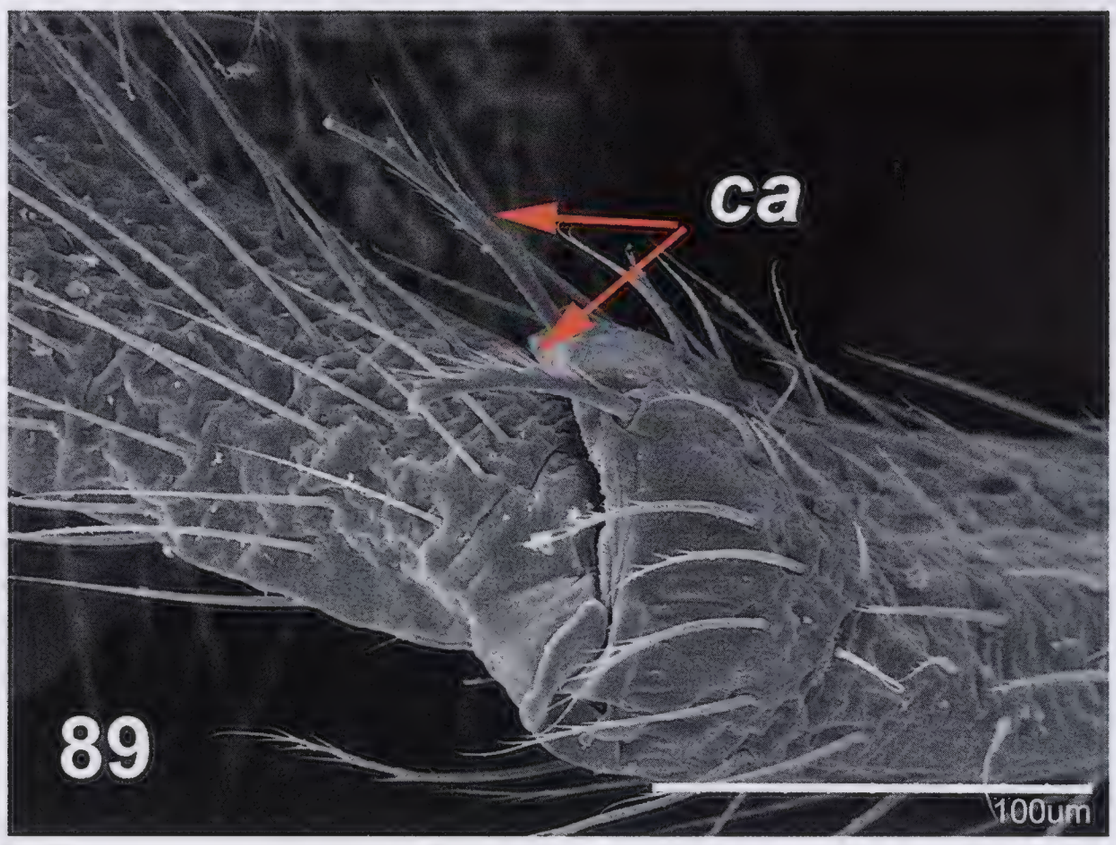


Figs 84-85. *Plusiocampa (Venetocampa) pirnati* Sendra & Borko, sp. nov. (84) Detail of mesonotum with clothing setae. (85) Detail of mesonotum with insertion of a clothing seta.







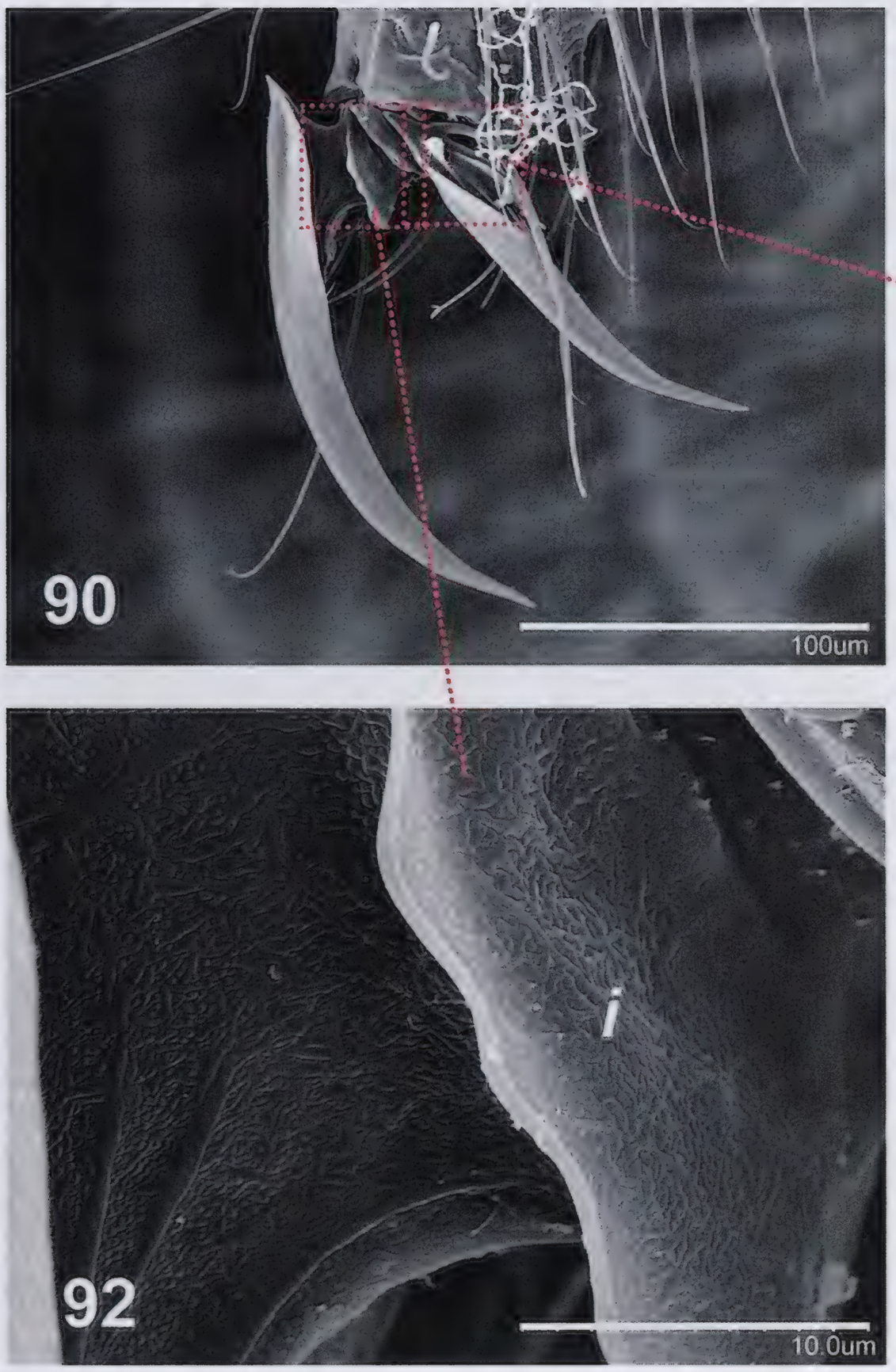


Figs 86-89. *Plusiocampa (Venetocampa) pirnati* Sendra & Borko, sp. nov. (86). Metathorax to eighth abdominal segment and metathoracic leg of a female, lateral view. (87) Central portion of femur of metathoracic leg with dorsal macrosetae (*dm*). (88) Central portion of tibia of metathoracic leg with two ventral macrosetae (v*m*). (89) Joint between tibia and tarsus of metathoracic leg with calcars (*ca*).

Abdomen: Urotergites III with 0+0 (rarely 0+1 $post_1$) macrosetae; urotergite IV with 0+0, 0+1 or 1+1 *la*, 1+1-2+1 $post_{1-2}$ macrosetae or 1+1-0+1 $spost_1$ submacrosetae; urotergite V with 1+1 *la*, 3+3-2+3 $post_{1-2,4}$ macrosetae or 2+1 $spost_{1-2}$ submacrosetae; urotergites VI-VII with 1+1 *la*, 4+4 $post_{1-4}$ macrosetae; urotergite VIII with 6+6 *post*; abdominal segment IX with 8+8 *post* macrosetae; all urotergal macrosetae long and barbed in distal three-fourths; urosternite I with 7+7 macrosetae; urosternites II-VII with 5+5; urosternite VIII with 2+2; urosternal macrosetae with a few long distal barbs. Apical seta with a basal tooth and two or three long thin barbs, subapical and medio-sternal setae with four or six long thin barbs (Fig. 96). Four cerci from four different specimens apparently complete and of similar length as body, except in ♀1 paratype (the largest) with cercus being 1.22 times longer than body; basal article divided into three or four secondary articles, followed by eight to eleven primary articles (Table 4); each primary cercus bearing two to ten irregular whorls of long barbed macrosetae, one to two distal whorls of smooth long setae, and one apical whorl of short thin setae with tiny distal barbs (Fig. 97).

Secondary sex characters: First urosternite of males carrying very large spherical appendages with a large field of up to 200 glandular a_1 setae (Figs 94-95); females with subcylindrical to conical appendages with up to 18 glandular a_1 setae.

Taxonomic affinities: The noticeable taxonomic traits in *Plusiocampa (Venetocampa) pirnati* sp. nov., such as the macroseta distribution pattern on nota and abdomen and the very unequal claws (posterior claw more than 1.5 longer than anterior claw), show strong similarities with *Plusiocampa* (*Plusiocampa*) *hoelzeli* (Neuherz, 1984), described from a cave in Carinthia (Austria) and recently reported from Renejevo brezno, Kanin Mountain, in Slovenia (Sendra *et al.,* 2020a) (uncertain affinity, see discussion below). The absence of glandular g_1 setae and the presence of huge spherical appendages

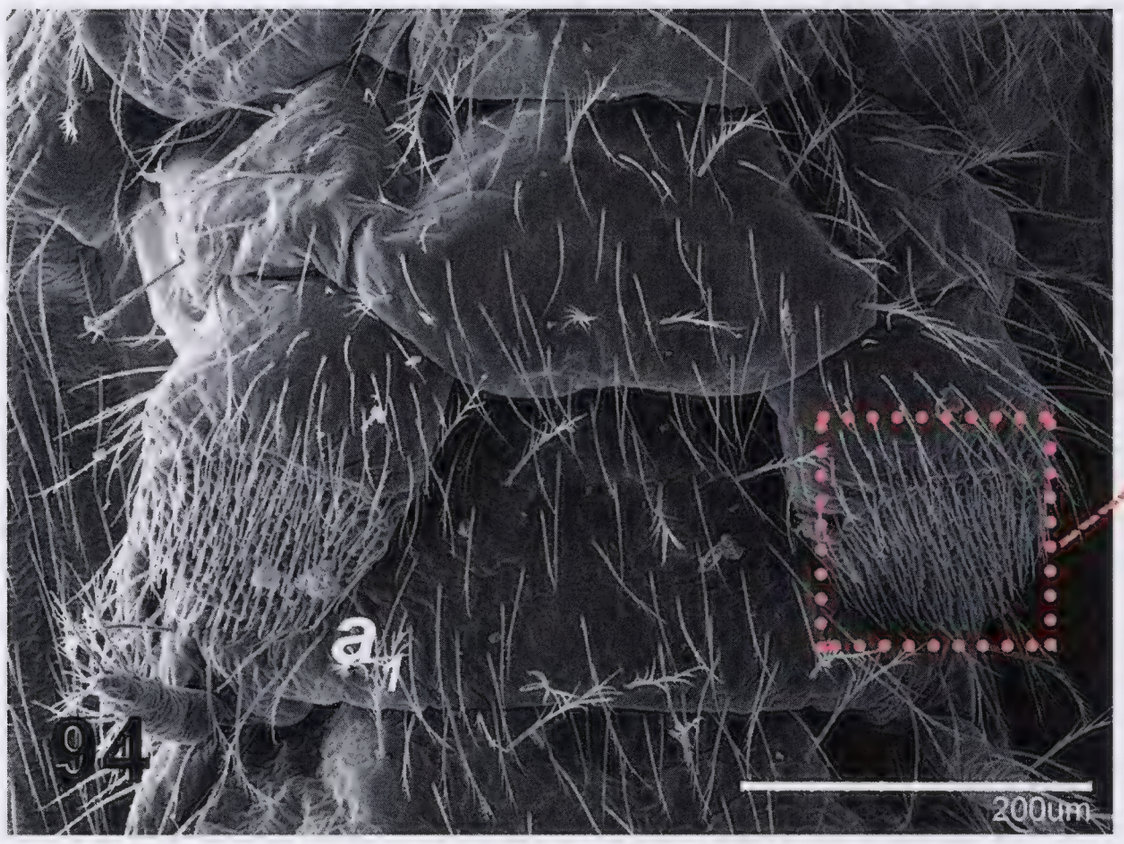


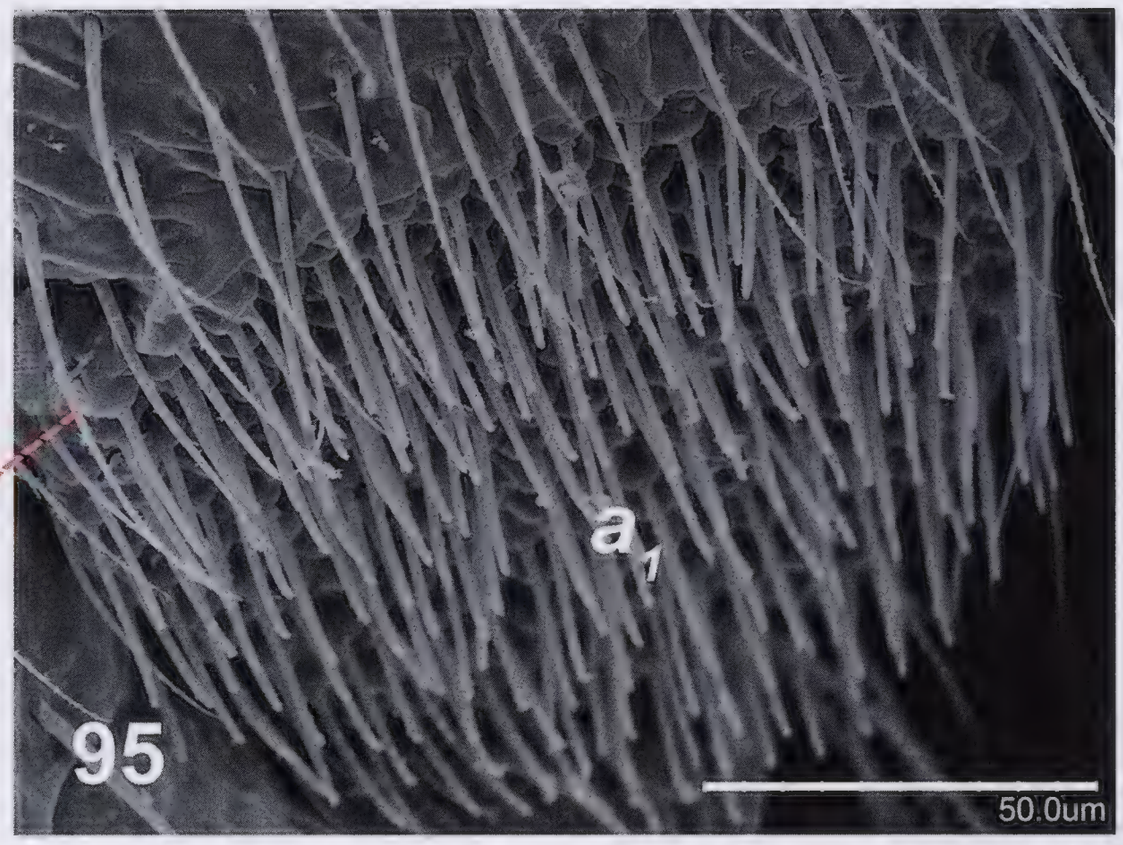
Figs 90-93. *Plusiocampa (Venetocampa) pirnati* Sendra & Borko, sp. nov. (90) Pretarsus of metathoracic leg, lateral view. (91) Detail of proximal portion of anterior claw in lateral view. (92) Detail of intermediate structure between claws (*i* = intermediate sheet). (93) Pretarsus of metathoracic leg, dorsal view.

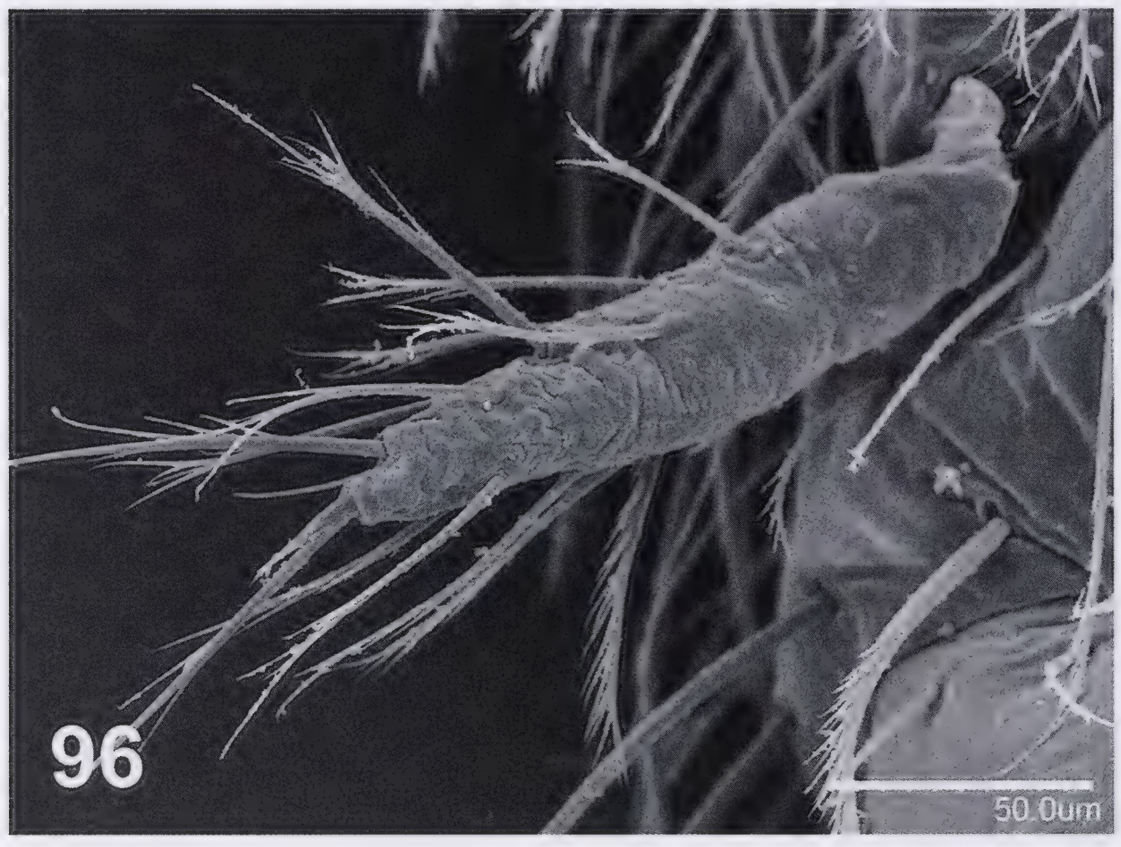
with numerous glandular a_1 setae in males show close similarities with *Plusiocampa* (*Venetocampa*) *paolettii* Bareth & Condé, 1984, described from a (not too distant) cave in Belluno, in the Italian Alps. At present, *P.* (*V.*) *paolettii* is considered to be closely related to *P. (V.) pirnati* sp. nov. and to belong in the controversial subgenus *Venetocampa* (see discussion). Both species are distinguished by the following traits: urotergal macrosetae present on the fourth urotergite, and 4+4 posterior macrosetae present on the sixth and seventh urotergite in *P. (V.) pirnati* sp. nov.; in *P. (V.) paolettii* the urotergal macrosetae on the fourth urotergite are absent and only 2+2 and 1+1 posterior macrosetae on the sixth and seventh urotergite are present; *P. (V.) pirnati* sp. nov. has 6+6 and 8+8 posterior macrosetae on the eighth urotergite, and on the ninth abdominal segment 4+4 macrosetae *vs.* 7+7 in *P. (V.) paolettii*. Lastly, *P. (V.) pirnati* sp. nov. has two or three ventral tibial macrosetae, whereas in *P. (V.) paolettii* such macrosetae are absent.

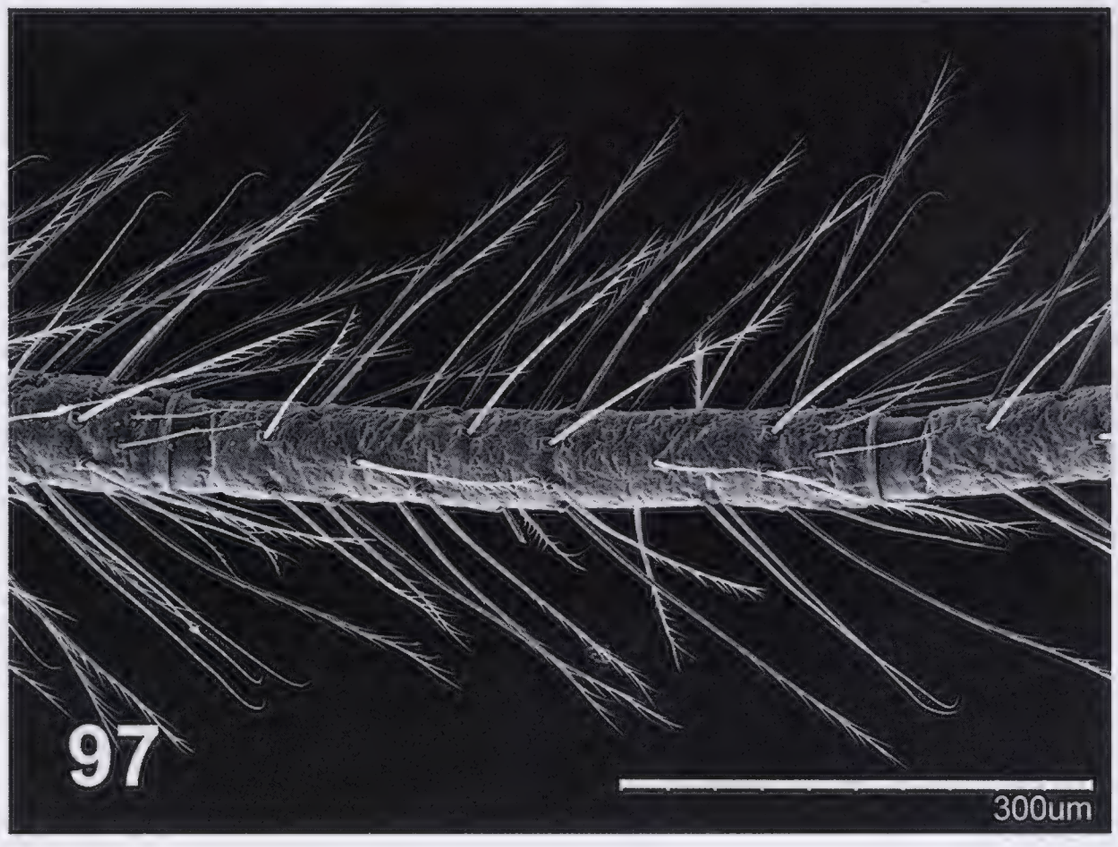
Type locality: Cave P4 (n. 1529) lies in the Kanin mountains (Bovec, Slovenia), in the western part of the Julian Alps (Figs 98-100). The cave entrance is located on the Kanin plateau, 2121 m above sea level, in a rocky area with an alpine vegetation. Cave P4 is part of a cave system that is 1320 m deep and 12 km long. The cave temperature varies with depth, from 1˚C in the upper parts to 3˚C at 1 km below the surface. Species richness and abundance is highest in the deeper parts of the cave. Animals were mostly collected with baited pitfall traps and very rarely by manual collecting from the surfaces. Most specimens were collected in the deep horizontal parts of the cave: always in wet areas, near constant drip water, on walls or in traps placed in gravel, but never on clay or sand. They were found together with *Anophthalmus* sp. beetles, Acari and several species of Collembola.

Renejevo brezno Cave (cave catalogue number 7090), where *Plusiocampa (Plusiocampa) hoelzeli* was found (Sendra *et al.,* 2020a), is part of the same cave system as









Figs 94-97. *Plusiocampa (Venetocampa) pirnati* Sendra & Borko, sp. nov. (94) First and second abdominal segment of a male, ventral view. (95) Apical portion of appendage of first urosternite with glandular a_1 setae in a male. (96) Stylus of fourth urosternite. (97) Fifth primary cercal article.

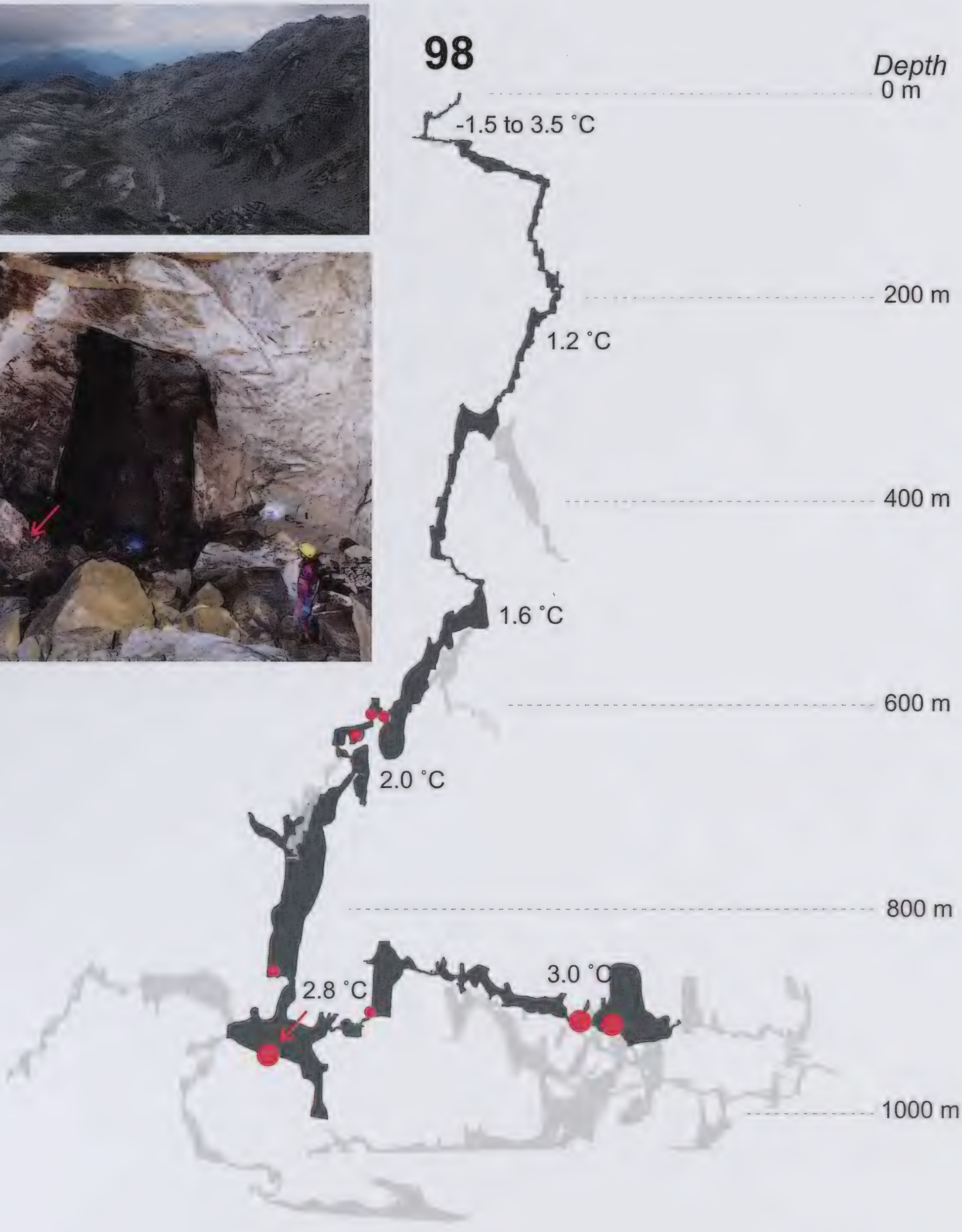
P4. The entrances of both caves are 1 km apart. In both caves diplurans were found at similar depths (always in deep parts of the caves). It is possible that the diplurans from Renejevo brezno Cave belong *to P. (V.) pirnati,* but the available specimens are too strongly damaged for a reliable identification. More diplurans from Renejevo brezno are needed to confirm taxonomic affinity.

DISCUSSION

Phylogeny, habitat and distribution: Diplurans are represented by 28 species of Campodeidae (one of the two dipluran families with troglobites around the world) in the cave ecosystems of the Dinarides, Eastern Alps, Balkan Mountains, and Rhodope Massif. Two out of five campodeid subfamilies inhabit this region: Campodeinae with one species and Plusiocampinae with 27 species.

The family Campodeinae comprises currently 355 species and worldwide distribution. It is characterized by a cuticle with roseate microstructures; the pronotal macrosetae formula is 1+1 medial anterior, 1+1 lateral anterior, 1+1 lateral posterior; the claws are subequal, simple, smooth, regularly curved and rarely have plain lateral crests; the uroterga carry up to one pair of medial and lateral anterior macrosetae and one to three pairs of lateral posterior macrosetae. Most Campodeinae live in soil habitats, and 15% of the species have adapted to cave ecosystems (Sendra *et al.,* 2020b). Its only representative in the study area is *Campodea (Paurocampa) pretneri* which occurs in the Eastern Alps and the western Dinaric Mountains (Table 5, Fig. 101).

Plusiocampinae have a Eurasian distribution, with 83% of the species living mostly in caves (Sendra *et al.*, 2020b). Two genera, the monotypic *Condeicampa* Ferguson, 1996 from a single cave in Nevada (USA), and *Silvestricampa* Condé, 1950, a genus with five soil-dwelling species from South Africa, are outside the main distribution area of Plusiocampinae in Eurasia. These species are characterized by a pronotum with at least 4+4 macrosetae, numerous lateral anterior and posterior



Figs 98-100. (98) Map of Cave P4 in the Kanin mountains (Bovec, Slovenia), with locations marked where *P. (V.) pirnati* sp. nov. was found. Cave passages that have been sampled at least once are marked in dark grey, whereas passages that have not been sampled yet are marked in light grey. Large red dots represent locations where we sampled five or more specimens, and small red dots are locations where less than five specimens where found. (99) View of the landscape from the cave entrance (photograph by Matic Di Batista). (100) Big chamber at 950 m depth where a high number of specimens were collected in one trap (red arrow indicates same location in Fig. 98 (photograph by Uroš Kunaver).

Table 5. Cave-adapted campodeids from the Dinarides, Eastern Alps, Balkan Mountains and Rhodope Massif.

Species	Dinarides	Eastern Alps	Balkan and Rhodope
Campodea (Paurocampa) pretneri Condé, 1974	*x*	*x*	
Plusiocampa (Didymocampa) cvijici Sendra & Antić, sp. nov.	*x*		
Plusiocampa (Plusiocampa) atom Sendra & Antić, sp. nov.	*x*		
Plusiocampa (Plusiocampa) bulgarica Silvestri, 1931			*x*
Plusiocampa (Plusiocampa) beroni Bareth & Condé, 2001			*x*
Plusiocampa (Plusiocampa) caprai Condé, 1950		*x*	
Plusiocampa (Plusiocampa) aff. *elongata* Ionescu, 1955			*x*
Plusiocampa (Plusiocampa) gueorguievi Bareth & Condé, 2001			*x*
Plusiocampa (Plusiocampa) hoelzeli (Neuherz, 1984)		*x*	
Plusiocampa (Plusiocampa) aff. *isterina* Condé, 1993	*x*		
Plusiocampa (Plusiocampa) friulensis Bareth & Condé, 1984		*x*	
Plusiocampa (Plusiocampa) grandii Silvestri, 1933		*x*	
Plusiocampa (Plusiocampa) latens Condé, 1948	*x*		
Plusiocampa (Plusiocampa) schweitzeri Condé, 1947	*x*		
Plusiocampa (Plusiocampa) strouhali Silvestri, 1933		*x*	
Plusiocampa (Plusiocampa) ternovensis Sendra & Borko, 2020 in Sendra *et al.*, 2020a	*x*		
Plusiocampa (Plusiocampa) vodniensis Bareth & Condé, 2001			*x*
Plusiocampa (Stygiocampa) barethae Sendra & Rađa, sp. nov.	*x*		
Plusiocampa (Stygiocampa) bureschi Silvestri, 1931			*x*
Plusiocampa (Stygiocampa) christiani Condé & Bareth, 1996	*x*		*x*
Plusiocampa (Stygiocampa) dalmatica Condé, 1959	*x*		
Plusiocampa (Stygiocampa) denisi Condé, 1947	*x*		
Plusiocampa (Stygiocampa) dulcici Sendra & Rađa, sp. nov.	*x*		
Plusiocampa (Stygiocampa) nivea (Joseph, 1882)	*x*		
Plusiocampa (Stygiocampa) remyi Condé, 1947	*x*		
Plusiocampa (Venetocampa) ferrani Sendra & Delić, 2020 in Sendra *et al.*, 2020a	*x*		
Plusiocampa (Venetocampa) paolettii Bareth & Condé, 1984		*x*	
Plusiocampa (Venetocampa) pirnati Sendra & Borko, sp. nov.		*x*	

macrosetae on several urotergites, and elbowed claws with mostly well-developed lateral crests. In our study area Plusiocampinae are represented by the hightly diversified genus *Plusiocampa* (divided into five subgenera), of which only the monotypic *Pentachaetocampa* Sendra & Weber, 2018, found in a single cave in southwestern Germany, is absent. The genus *Plusiocampa* has 76 described species, most of which are cave-adapted, although 16 of these species lack troglomorphic features. These species live in the soil and occasionally reach the deepest soil layer, sometimes called the mesovoid shallow substratum, and they are rarely found in caves (Sendra *et al.,* 2020a). In the study area there are species of four subgenera: *Didymocampa* Paclt, 1957 with one species described herein; *Plusiocampa* s. str. Silvestri, 1912 with 15 species including one described herein; *Stygiocampa* Silvestri, 1934 with eight species of which two are described herein; and *Venetocampa* Bareth & Condé, 1984 with three species, including one described herein (Table 5, Fig. 102).

Didymocampa was established on the basis of the presence of two dorsal femora macrosetae in two species from distant localities: *P. (D.) evallonychia* from a Crimean cave and *Plusiocampa sinensis* Silvestri, 1931 found in Chinese soil (Paclt, 1957). Much later Condé & Sendra (1989) added one more species from a cave

in the south of the Iberian Peninsula, *Plusiocampa (Didymocampa) alhamae* Condé & Sendra, 1989. Condé (1993) described a new cave-adapted species from China, *Plusiocampa (Didymocampa) lipase* Condé, 1993, and last Condé (1996) added one more species from Movile Cave in Romania, *P. (D.) euxina* Condé, 1996. Recently, the disjunct subgenus *Didymocampa* started to crumble; *P. (D.) lipsae* was transferred to *Hubeicampa* Sendra & Lips in Sendra *et al.,* 2020b, to which the highly cave-adapted Chinese species *Hubeicampa melissa* Sendra & Lips, 2020 in Sendra *et al.,* 2020b was added. It is also necessary to reconsider the position of *P. sinensis* due to the presence of 1+1 macrosetae on the eighth urosternite, which is not present in any other *Plusiocampa* species (Sendra *et al.,* 2020b). We suggest keeping the subgenus *Didymocampa* for the European species, including *Plusiocampa (Didymocampa) cvijici* sp. nov. from the Dinarides (Fig. 102).

The subgenus *Plusiocampa* has 58 described species of which 73% are exclusively found in caves (Sendra *et al.,* 2020a). They are spread over the Euro-Mediterranean region, from southern Europe and a small karst area in northern Africa (Kabylian Mountains, Tell Atlas) throughout the south of Central Europe to southeastern Europe, together with some isolated localities in the Anatolian and Crimean peninsulas and in the western Caucasus (Sendra *et al.,* 2020a). *Plusiocampa* s. str. seems to be a monophyletic group because species share numerous macrosetae on nota and urotergites and possess one dorsal femoral macroseta and 1-4 ventral tibial macrosetae. The presence or absence of medial posterior macrosetae on the mesonotum and metanotum splits *Plusiocampa* s. str. into two biogeographically distinct subgroups (Condé, 1956; Sendra *et al.,* 2019; Sendra *et al.,* 2020c). In our study area six species of *Plusiocampa* s. str. belong to the group without thoracic medial posterior macrosetae. They presumably evolved on the Dinaric plate. *Plusiocampa atom* sp. nov., *P.* aff. *isterina, P. latens, P. schweitzeri* and *P. ternovensis* occur in the Dinarides, and only one species, *P. gueorguievi,* lives in Central Predbalkan caves. Nine species belong to the group with medial posterior macrosetae on the thorax, representing recent colonizers of the surroundings of the Dinarides: *P. caprai, P. friulensis, P. grandii, P. hoelzeli* and *P. strouhali* inhabit the Eastern Alps, and *P. bulgarica, P. beroni, P.* aff. *elongata* and *P. vodniensis* live in the Balkan System (Stara Planina) and in the Rhodope Massif (Table 5, Fig. 103).

Most species in the subgenus *Stygiocampa* are restricted to the Dinaric Karst: *P. (S.) barethae* sp. nov., *P. (S.) dalmatica, P. (S.) denisi, P. (S.) dulcici* sp. n., *P. (S.) nivea* and *P. (S.) remyi*. In addition, *P. (S.) christiani* and *P. (S.) bureschi* can be found in the Balkan Mountains (Table 5, Fig. 104). *Stygiocampa* is a presumably monophyletic group of large species in the genus *Plusiocampa* (6-9 mm body size), which are highly adapted to cave ecosystems and characterized by a trend towards macrosetae reduction on nota, urotergites and legs. They show noticeable troglomorphic features, including a peculiar cupuliform organ with a very narrow entrance, complex and unique olfactory chemoreceptors, long antennae and legs, and mostly long cerci that are two times (or almost three times) the body length (Condé, 1956; Sendra *et al.,* 2020a). Two groups within *Stygiocampa* can be defined based on the presence or absence of extra macrosetae on the first to the eighth urosternites. *Plusiocampa (S.) barethae* sp. nov., *P. (S.) christiani, P. (S.) dalmatica, P. (S.) nivea* and *P. (S.) remyi* have extra macrosetae (18+18-24+24, 11+11-15+15, 3+3-4+4 macrosetae formula on first, second to seventh and eighth urosternite, respectively), whereas *P. (S.) bureschi, P. (S.) denisi* and *P. (S.) dulcici* sp. nov. have no extra urosternal macrosetae (7+7, 5+5, 2+2 macrosetae instead).

The subgenus *Venetocampa* has three species [*P. (V.) ferrani, P. (V.) paolettii* and *P. (V.) pirnati* sp. nov.] that occur between the Italian and Slovenian Alps, the Eastern Alps and the extreme northwest of the Dinarides (Table 5, Fig. 102). *Venetocampa* is defined by the presence of one dorsal femoral macroseta, in addition to the absence of ventral tibial macrosetae, which is a combination of characters close to that present in *Plusiocampa* s. str. and *Stygiocampa*. The three *Venetocampa* species have other chracteristics in common with *P. (P.) ternovensis* and *P. (P.) hoelzeli,* such as their small body sizes, unequal anterior and posterior claws, and occurrence in cave ecosystems. Interestingly, all species except *P. (V.) ferrani* are from caves located at high altitudes, with *P. (V.) ferrani* also found in a relatively deep cave (-350 m) although not in the mountains. At least three species are known from great depths: *P. (P.) ternovensis* from 900 m below ground, *P. (V.) pirnati* sp. nov. from -1000 m, and *P. (P.) hoelzeli* from -1200 m which holds the record of being the dipluran from the deepest cave locality.

Biodiversity and distribution patterns in the Dinaric and adjacent karst regions: The Dinarides is a region with high endemicity of troglobionts from many different terrestrial arthropod groups (Bedek *et al.,* 2011; Hlavač *et al.,* 2017). The geographical ranges of these troglobionts are generally small and fragmented (Trontelj *et al.*, 2009; Zagmajster *et al.,* 2014; Bregović *et al.,* 2019). Our data on cave-dwelling campodeids in the Dinarides and adjacent regions revealed a somewhat different pattern. Most of the troglobiotic dipluran species have large ranges, in particular species of the subgenus *Stygiocampa,* such as *Plusiocampa (Stygiocampa) nivea*, *Plusiocampa (Stygiocampa) remyi* and the extreme case of *Plusiocampa (Stygiocampa) dalmatica,* with a maximum distance of 350 km between localities (Fig. 104). Such large ranges are rare for terrestrial troglobionts and have been recorded only within some taxonomic groups such as centipedes, millipedes, isopods and spiders (Antić *et al.,* 2015; Karaman & Horvatović, 2018; Stoev, 2001). Large ranges are probably methodological artefacts, i.e.

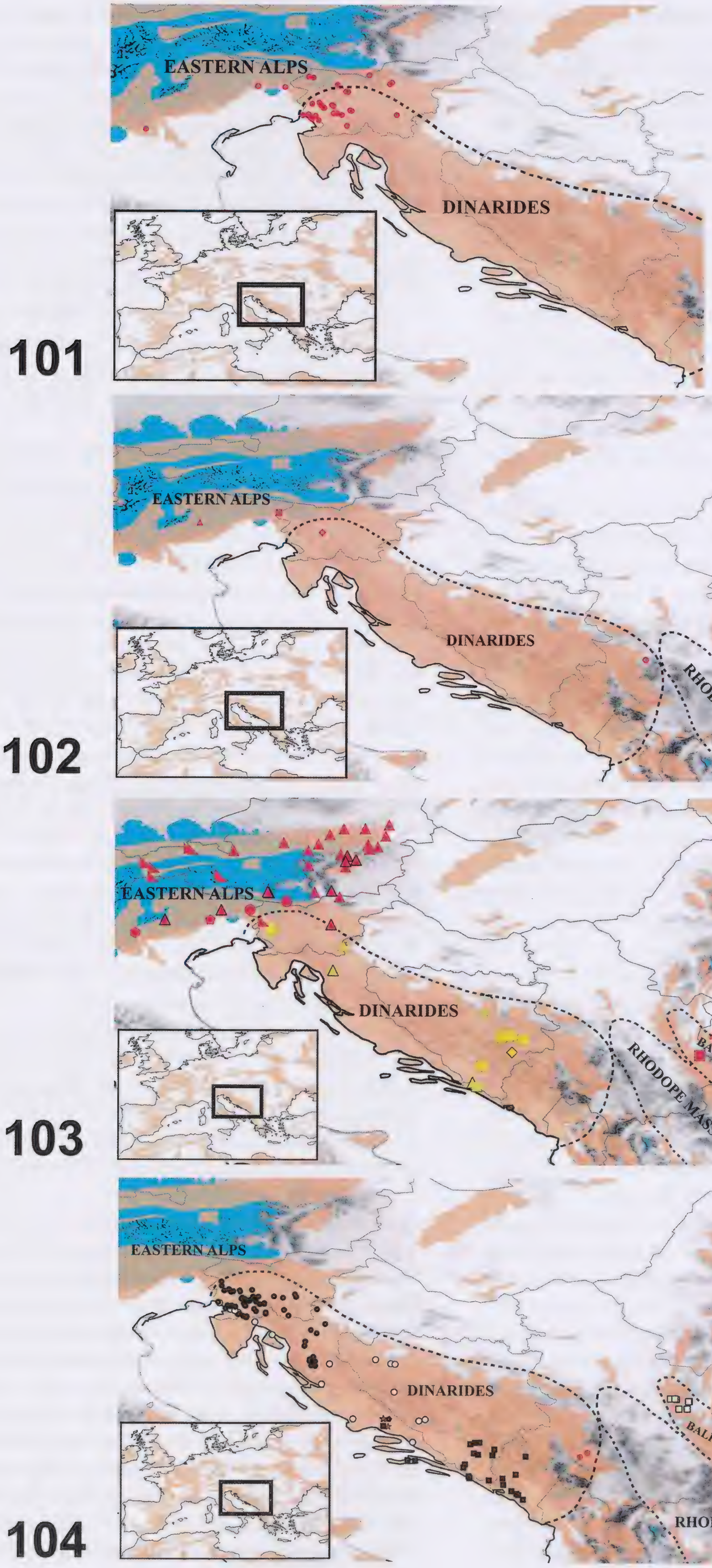

EASTERN ALPS
DINARIDES
101
EASTERN ALPS
DINARIDES
BALKAN MOUNTAINS
RHODOPE MASSIF
102
EASTERN ALPS
DINARIDES
BALKAN MOUNTAINS
RHODOPE MASSIF
103
EASTERN ALPS
DINARIDES
BALKAN MOUNTAINS
RHODOPE MASSIF
104

Fig. 101. Localities of *Campodea (Paurocampa) pretneri* Condé, 1974 (red circles). In brown: karst areas (source: Chen *et al.,* 2017). In blue: ice cover during the Last Glacial Maximum (source: Ehlers *et al.,* 2011).

Fig. 102. Localities of *Plusiocampa (Venetocampa) paolettii* Bareth & Condé, 1984 (red triangle), *Plusiocampa (Venetocampa) pirnati* Sendra & Borko, sp. nov. (red square), *Plusiocampa (Venetocampa) ferrani* Sendra & Delić, 2020 in Sendra *et al.,* 2020a (red diamond) and *Plusiocampa (Didymocampa) cvijici* Sendra & Antić, sp. nov. (red circle). In brown: karst areas (source: Chen *et al.,* 2017). In blue: ice cover during the Last Glacial Maximum (source: Ehlers *et al.,* 2011).

Fig. 103. Localities of *Plusiocampa (Plusiocampa) strouhali* Silvestri, 1933a (red triangles), *Plusiocampa (Plusiocampa) hoelzeli* (Neuherz, 1984) (red circles), *Plusiocampa (Plusiocampa)* aff. *elongata* Ionescu, 1955 (red squares), *Plusiocampa (Plusiocampa) caprai* Condé, 1950 (red half squares), *Plusiocampa (Plusiocampa) friulensis* Bareth & Condé, 1984 (red pentagon), *Plusiocampa (Plusiocampa) grandii* Silvestri, 1933b (red hexagon), *Plusiocampa (Plusiocampa) bulgarica* Silvestri, 1931 (red crosses), *Plusiocampa (Plusiocampa) beroni* Bareth & Condé, 2001 (red semicircles), *Plusiocampa (Plusiocampa) vodniensis* Bareth & Condé, 2001 (red arrow), *Plusiocampa (Plusiocampa) ternovensis* Sendra & Borko, 2020 in Sendra *et al.,* 2020a (yellow circles), *Plusiocampa (Plusiocampa) atom* Sendra & Antić, sp. nov. (yellow star), *Plusiocampa (Plusiocampa) latens* Condé, 1948 (yellow triangles), *Plusiocampa (Plusiocampa) schweitzeri* Condé, 1947 (yellow squares), *Plusiocampa (Plusiocampa)* aff. *isterina* Condé, 1993 (yellow diamond), *Plusiocampa (Plusiocampa) gueorguievi* Bareth & Condé, 2001 (yellow cross). In brown: karst areas (source: Chen *et al.,* 2017). In blue: ice cover during the Last Glacial Maximum (source: Ehlers *et al.,* 2011).

Fig. 104. Localities of *Plusiocampa (Stygiocampa) nivea* (Joseph, 1882) (black circles), *Plusiocampa (Stygiocampa) dalmatica* Condé, 1959 (white circles), *Plusiocampa (Stygiocampa) remyi* Condé, 1947 (black squares), *Plusiocampa (Stygiocampa) christiani* Condé & Bareth, 1996 (white squares), *Plusiocampa (Stygiocampa) barethae* Sendra & Rađa, sp. nov. (black hexagon), *Plusiocampa (Stygiocampa) dulcici* Sendra & Rađa, sp. nov. (red stars), *Plusiocampa* (*Stygiocampa*) *denisi* Condé, 1947 (red circles) and *Plusiocampa (Stygiocampa) bureschi* Silvestri, 1931 (red squares). In brown: karst areas (source: Chen *et al.,* 2017). In blue: ice cover during the Last Glacial Maximum (source: Ehlers *et al.,* 2011).

morphology alone, without molecular analyses, cannot untangle taxonomic relationships within subterranean groups with a multitude of cryptic species. Another peculiar feature of campodeid diversity is that there are no endemic genera or subgenera in the Dinarides in constrast to all other taxonomic groups that have strongly diversified in the subterranean habitats of the region. Cave-adapted species of the subgenera *Campodea (Paurocampa)* and *Plusiocampa (Venetocampa)* are distributed across the Eastern Alps and western Dinarides, representing Alpine-Dinaric lineages, a pattern documented in several other taxonomic groups (Antić *et al.,* 2018). *Plusiocampa (Plusiocampa)* and *Plusiocampa (Didymocampa)* have a wide Euro-Mediterranean distribution. *Plusiocampa (Stygiocampa)* exhibits a holodinaric distribution, but two species are also known to be present in the Kučaj and Beljanica Mountains, in the Serbia and Stara Planina Mountains (all part of the Balkan Mountains) (Figs 101-104). The alternating range pattern of different subgenera, together with their regional overlaps, suggest complex colonization and speciation events of the subterranean habitats in the study regions. This is particulary evident in Slovenia, at the junction of the Dinaric and the Alpine biogeographic regions, where the pattern of co-occurrences of Alpine and Dinaric lineages was already documented in different cave groups (Faille *et al.,* 2013).

Colonization: Multiple hypotheses have been suggested to explain the colonization of the Euro-Mediterranean basin by campodeid diplurans (Sendra *et al.*, 2004; Sendra *et al.,* 2019; Sendra *et al.,* 2020a, c, d). These colonization hypotheses use families, subfamilies, genera, and subgenera of cave-adapted species of campodeids as groups to compare with their current well-known distribution ranges. Thus, we suggest that dispersal, vicariance and extinction processes that have taken place during hundreds of millions of years explain the current distribution of cave campodeids in the Balkan region. No tachycampoids species, *Podocampa* or *Litocampa* (a presumably monophyletic linage in the subfamily Campodeinae), are present in either the central or eastern Euro-Mediterranean karst regions. Tachycampoids, *Podocampa* and *Litocampa* occur in the extreme western European karst regions, with disjunct distribution ranges at both sides of the Atlantic Ocean, and they are considered as relicts of Pangea from the Mesozoic (Sendra *et al.,* 2020a). At the beginning of the Cenozoic, new European microplates emerged and gave the opportunity for new colonization (Sendra *et al.,* 2004; Sendra *et al.,* 2019). In such a paleogeographical scenario Plusicampinae could have arrived through two possible connections from eastern Laurasia: one when the Turgai Strait closed during the Eocene-Oligocene transition (Decourt *et al.,* 2000), and another, more recent, at the beginning of Miocene, through the Anatolian peninsula to the Balkans (Sendra *et al.,* 2004). Both connections could have allowed the arrival of the first Plusiocampinae wave represented by Plusiocampinae species without medial macrosetae on the mesonotum and metanotum. This hypothetic monophyletic group contains all *Stygiocampa, Venetocampa, Pentachaetocampa, Patrizicampa* and *Cycladicama* species, as well as some species

of *Cestocampa, Didymocampa* and *Plusiocampa* s. str. These first newcomers are currently located in the Dinaric karst, Gargano Promontory, and the rest of the Protoliguric massif: Catalanides Range, Sardinia, Kabylias and Internal Baetic Zone, in addition to the small Irakelia Island in the Cyclades Islands where *Cycladicampa* Sendra, 2020 has been recently discovered (Sendra *et al.,* 2020c). A second wave of Plusiocampinae could have colonized the land emerging during the Messinian, at the end of the Miocene. These second newcomers are represented by Plusiocampinae with medial macrosetae on the mesonotum and metanotum, as in many species of *Plusiocampa* s. str., including also *Vandelicampa, Hystrichocampa,* some *Didymocampa* and *Cestocampa* species (Sendra *et al.,* 2019). This second lineage is currently distributed in the external Baetic Mountains, Rhone Valley region, Alpes, Italian peninsula, and many Mediterranean islands such as the Balearic Islands or Crete. The Dinarides harbour only ancestors of the first wave of colonizers, that is Plusiocampinae with medial macrosetae: *Stygiocampa, Didymocampa, Venetocampa* and *Plusiocampa* s. str. species. Adjacent karst regions, such as the Alps and the Balkan Mountains, received only *Plusiocampa* species from the second colonization wave, that is Plusiocampinae without medial macrosetae. Relatively stable climatic conditions inside caves and their subterrestrian surroundings allowed campodeids to survive in Dinaric cave-ecosystems during the Cenozoic. The diplurans from regions to the north of the Dinarides were wiped out during the Pleistocene glaciations (Sendra *et al.,* 2020c).

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REFERENCES

Antić D.Ž., Makarov S.E. 2019. The Balkan Peninsula – one of the world's major hotspots of troglobitic millipedes (Myriapoda: Diplopoda) (p. 15). *In*: Delić T., Zagmajster M., Borko Š., Fišer Ž., Premate E., Fišer C., Trontelj P. (eds). 2nd Dinaric Symposium on Subterranean Biology, Postojna, Slovenia, 18-19 October 2019. *Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani, Ljubliana.*

Antić D.Ž., Ćurčić B.P.M., Tomić V.T., Rađa T., Rađa B., Milinčić M.A., Makarov S.E. 2013. Two new species of *Brachydesmus* Heller, 1858 from Balkan Peninsula (Diplopoda: Polydesmida; Polydesmidae). *Archives of Biological Sciences* 65: 1233-1243.

Antić D.Ž., Reip H.S., Dražina T., Rađa T., Makarov S.E. 2014. Three new monotypic genera of Trichopolydesmidae from Croatia, Balkan Peninsula (Diplopoda, Polydesmida). *Zootaxa* 3884(2): 101-121.

Antić D.Ž., Dražina T., Rađa T., Tomić V.T., Makarov S.E. 2015. Review of the family Anthogonidae (Diplopoda, Chordeumatida), with descriptions of three new species from the Balkan Peninsula. *Zootaxa* 3948(2): 151-181.

Antić D.Ž., Dražina T., Rađa T., Lučić L.R., Makarov S.E. 2018. Review of the genus *Typhloiulus* Latzel, 1884 in the Dinaric region, with a description of four new species and the first description of the male of *Typhloiulus insularis* Strasser, 1938 (Diplopoda: Julida: Julidae). *Zootaxa* 4455(2): 258-294.

Bareth C. 1988. Campodés cavernicoles de la Vénétie orientale (Frioule, Vénétie Julienne) et de la Calabre (Insecta, Aptérygota, Diplura). *Atti e Memorie della Commissione Grotte «E. Boegan»* 27: 45-55.

Bareth C., Condé B. 1981. Nouveaux Campodéidés de grottes d'Espagne. *Revue suisse de Zoologie* 88(3): 775-786.

Bareth C., Condé B. 1984. Nouveaux *Plusiocampa* cavernicoles d'Italie continentale (Diplura, Campodeidae). *Bollettino della Società entomologica italiana* 116(8-10): 132-147.

Bareth C., Condé B. 2001. Campodéidés des grottes de Bulgarie (Insecta: Diplura). *Mémoires de biospéologie* 28: 9-27.

Bedek J., Gottstein S., Taiti S. 2011. Catalogue and atlas of cave-dwelling terrestrial isopods (Crustacea: Oniscidea) from Croatia. *Natura Croatica* 20: 237-354.

Bogićević K., Nenadić D., Milošević S., Mihailović D., Vlastić S., Tošović R. 2017. A Late Pleistocene rodent fauna (Mammalia: Rodentia) from Hadzi Prodanova Cave near Ivanjica (Western Serbia). *Rivista Italiana di Paleontologia e Stratigrafia* 123(1): 23-38.

Bregović P., Fišer C., Zagmajster M. 2019. Contribution of rare and common species to subterranean species richness patterns. *Ecology and Evolution* 9: 11606-11618.

Chen Z., Auler A., Bakalowicz M., Drew D., Griger F., Hartmann J., Jiang G., Moosdorf N., Richts A., Stevanović Z., Veni G., Goldscheider N. 2017. The World Karst Aquifer Mapping project: concept, mapping procedure and map of Europe. *Hydrogeology Journal* 25: 771-785.

Condé B. 1947. Campodéidés nouveaux des grottes Balkaniques. *Notes biospéologiques* 1: 17-32.

Condé B. 1948. Description d'un *Plusiocampa* cavernicole nouveau de l'Herzégovine. *Notes biospéologiques* 2: 49-51.

Condé B. 1950. Description d'un Campodéidé cavernicole de Lombardie. *Doriana (Annali del Museo Civico di Storia Naturale "G. Doria")* 1(3): 1-4.

Condé B. 1956. Matériaux pour une monographie des Diploures Campodéidés. *Mémoires du Muséum National d'Histoire naturelle, Série A-Zoologie* 12: 1-202.

Condé B. 1959. Un singulier diploure cavernicole de Dalmatie. *Fragmenta Balcanica* 2(20): 165-172.

Condé B. 1974. Les *Paurocampa* du groupe de *suensoni* Tuxen dans les grottes d'Europe centrale (Diploures, Campodéidés). *Revue suisse de Zoologie* 81(2): 561-567.

Condé B. 1993. Premiers Campodeidae cavernicoles de Chine, comme exemple de l'évolution souterraine de la famille (Diplura). *Revue suisse de Zoologie* 100(4): 823-828.

Condé B. 1996. Diploures Campodéidés de la Peştera de la Movile (Movile Cave), Dobroudja méridionales (Roumanie). *Revue suisse de Zoologie* 103(1): 101-114.

Condé B., Bareth C. 1996. Une évaluation de *Stygiocampa*, sous-genre troglomorphe du *Plusiocampa* (Diplura, Campodeidae), avec la description d'une nouvelle espèce de Serbie orientale. *Revue suisse de Zoologie* 103(2): 369-381.

Condé B., Sendra A. 1989. Description du premier Campodéidé cavernicole du sud de la péninsule Ibérique (Diplura, Campodeidae). *Revue suisse de Zoologie* 96(3): 611-617.

Culver D.C., Deharveng L., Bedos A., Lewis J., Madden M., Reddell J.R., Sket B., Trontelj P., White D. 2006. The mid-latitude biodiversity ridge in terrestrial cave fauna. *Ecography* 29: 120-128.

Curčić B.P.M., Lučić L.R., Boškova T.D. 1999. *Pseudosinella ivanjicae*, a new endemic and cave species from West Serbia, Yugoslavia (Collembola: Entomobryidae). *Archives of Biological Sciences* 51: 63-64.

Decourt J., Gaetani M., Vrielynck B., Barrier E., Biju-Duval B., Brunet M.F., Cadet J.P., Crasquin S., Sandulescu M. 2000. Atlas of Peri-Tethys palaeogeographical maps. *CCGM, Paris*, 78 pp.

Denis J.R. 1923. Notes sur les Aptérygotes. Ordo: Diplura C.B. *Annales de la Société Entomologique de France* 92: 231-236.

Ehlers J., Gibbard P.L., Hughes P.D. 2011. Quaternary glaciations - extent and chronology. *Elsevier, Amsterdam,* 1108 pp.

Faille A., Casale A., Balke M., Ribera I. 2013. A molecular phylogeny of Alpine subterranean Trechini (Coleoptera: Carabidae). *BMC Evolutionary Biology* 13, 248. https://doi.org/10.1186/1471-2148-13-248

Ferguson L.M. 1996. *Condeicampa langei*, new genus and species of Dipluran (Diplura: Campodeidae) from Whipple Cave, Nevada, USA. *Mémoires de biospéologie* 23: 133-141.

Guéorguiev B.V., Ćurčić S.B., Ćurčić B.P.M. 2000. A new troglobitic ground-beetle, *Duvalius (Neoduvalis) starivlahi* (Coleoptera: Carabidae: Trechini), from Southwestern Serbia. *Archives of Biological Sciences* 52: 227-230.

Hlaváč P., Perreau M., Čeplík D. 2017. The subterranean beetles of the Balkan peninsula. *Czech University of Life Sciences, Faculty of Forestry and Wood Sciences, Department of Forest Protection and Entomology, Praha,* 267 pp.

Ionescu M.A. 1955. Diplura. Fauna Republicii Populare Române, Insecta VII (2). *Bucareşti, Acedemiei Republicii Populare Romane,* 48 pp.

Joseph G. 1882. Systematisches Verzeichniss der in den Tropfstein-Grotten von Krain einheimischen Arthropoden nebst Diagnosen der vom Verfasser entdeckten und bisher noch nicht beschriebenen Arten. *Berliner entomologische Zeitschrift* 26: 24-31.

Karaman I.M., Horvatović M. 2018. Revision of the genera *Cyphonethes* Verhoeff, 1926 and *Titanethes* Schioedte, 1849 (Isopoda: Oniscoidea: Trichoniscidae) with a description of a new genus and three new taxa. *Zootaxa* 4459(2): 261-284.

Koch L. 1867. Zur Arachniden- und Myriapoden-Fauna Süd-Europas. *Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien* 17: 891-900.

Koch M. 2009. Diplura (pp. 281-283). *In:* Resh V.H., Cardé R.T. (eds). Encyclopedia of Insects, 2nd edition. *Elsevier, Amsterdam*, 1132 pp.

Kuščer L. 1933. Prispevek k poznavanju podzemskih gastropodov Dalmacije in Hercegovine. *Prirodoslovna Istraživanja Kraljevine Jugoslavije* 18: 59-67.

Lukić-Bilela L., Mulaomerović J., Tulić U., Habul A., Softić A., Katica V. 2009. Morphometric parameters of cranial and postcranial skeleton in cave bear (*Ursus spelaeus* Rosenmüller & Heinroth, 1794) from Lukina pećina cave and Megara in Bosnia and Herzegovina. *Veterinaria* 58(1-2): 83-96.

Meinert F. 1865. Campodea: en familie af Thysanurernes orden. *Naturhistorisk Tidsskrift* 3: 400-440.

Mihailović D., Mihailović B. 2003. The Palaeolithic site Hadži Prodan's Cave by Ivanjica. *Archaeological Reports of the Serbian Archaeological Society* 1: 13-16.

Miller L. 1861. *Anophthalmus dalmatinus* n. sp. *Wiener Entomologische Monatschrift* 5: 255-256.

Neuherz H. 1984. *Torocampa hölzeli* n. gen., n. spec. - eine klasobionte Campodeide (Diplura, Apterygota) aus der Hafnerhöhle in den Karawanken, Kärnten. *Carinthia II* 174/94: 415-427.

Paunović M. 2016. Distribution, ecology and centres of bat diversity (Mammalia, Chiroptera) in Serbia. *Doctoral Thesis, University of Belgrade, Faculty of Biology, Belgrade, Serbia*, 479 pp. [in Serbian, English summary].

Paclt J. 1957. Diplura. *Genera Insectorum (publiés par P. Wytsman)* 212: 1-123.

Roewer C.-F. 1917. Über Nemastomatiden und ihre Verbreitung. *Archiv für Naturgeschichte* 83A(2): 140-160.

Sendra A., Weber D. 2018. An unexpected discovery of a new subgenus and a species of *Plusiocampa* (Campodeidae, Diplura) alongside an overview of Central European subterranean campodeids. *European Journal of Taxonomy* 428: 1-21.

Sendra A., Lara M.A., Ruiz Aviles F., Tinaut A. 2004. Une nouvelle espèce du genre *Plusiocampa* Silvestri, 1912 (Diplura, Campodeidae) et données pour sa reconstruction paléobiogéographique dans les Bétiques. *Subterranean Biology* 2: 113-122.

Sendra A., Nicolosi G., Amore E. 2019. Subterranean Campodeidae fauna from Sicily (Diplura): its bio-geographical interest with the description of a new species of *Plusiocampa*. *Zootaxa* 4679(2): 297-317.

Sendra A., Antić D., Barranco P., Borko Š., Christian E., Delić T., Fadrique F., Faille A., Galli L., Gasparo F., Georgiev D., Giachino P.M., Kováč L., Lukić M., Marcia P., Miculinić K., Nicolosi G., Palero F., Paragamian K., Pérez T., Polak S., Prieto C.E., Turbanov I., Vailati D., Reboleira A.S.P.S. 2020a. Flourishing in subterranean ecosystems: Euro-

Mediterranean Plusiocampinae and tachycampoids (Diplura, Campodeidae). *European Journal of Taxonomy* 591: 1-138.

Sendra A., Komerički A., Lips J., Yunxia L., Selfa J., Jimenez-Valverde A. 2020b. Asian cave-adapted diplurans, with the description of two new genera and four new species (Arthropoda, Hexapoda, Entognatha). *European Journal of Taxonomy* (in press).

Sendra A., Nikoloudakis I., Gavalas I., Selfa J., Paragamian K. 2020c. A surprising new genus and species of cave adapted Plusiocampinae *Cycladiacampa irakleiae* (Diplura, Campodeidae) from Irakleia Island, Cyclades Islands in the Aegean Archipelago (Greece). *Subterranean Biology* 35: 15-32.

Sendra A., Palero F., Jimenez-Valverde A., Selfa J., Reboleira A.S.P.S. 2020d. Diplura in caves: diversity, ecology, evolution and biogeography. *Zoological Journal of the Linnean Society,* zlaa116, https://doi.org/10.1093/zoolinnean/zlaa116.

Sendra A., Jiménez-Valverde A., Selfa J., Reboleira A.S.P.S. 2021. Diversity, ecology, distribution and biogeography of Diplura. *Insect Conservation and Diversity*, DOI: 10.1111/icad.12480 (In Production).

Silvestri F. 1912. Contribuzione alla conoscenza dei Campodeidae (Thysanura) d'Europa. *Bolletino del Laboratorio di Zoologia generale e agraria in Portici* 6: 110-147.

Silvestri F. 1931. Contributo alla conoscenza dei Campodeidae (Thysanura) della grotte della Bulgaria. *Bulletin de l'Institut royal d'Histoire naturelle Sofia* 6: 97-10.

Silvestri F. 1933a. Beschreibung einer neuen cavernicolen *Plusiocampa*-Art (Campodeidae). *Mitteilungen über Höhlen- und Karstforschung* 3: 30-33.

Silvestri F. 1933b. Descrizione di una nuova specie cavernicola di Campodeidae (Thysanura, Entothropha) del Trentino. *Bollettino del Laboratorio di Entomologia agraria de Bologna* 6: 1-4.

Silvestri F. 1934. Tisanuri cavernicoli della regione di Postumia. (pp. 179-181). *In:* Atti del I Congresso Speleologico Nazionale, Giugno, 1933, Trieste. *Milano, Società graphica G. Modiano,* 252 pp.

Silvestri F. 1947. Illustrazione della *Plusiocampa (Stygiocampa) nivea* Joseph (Campodeidae, Diplura) della grotte di Postumia. *Bolletino del Laboratorio d'Entomologia agraria in Portici* 8: 88-92.

Silvestri F. 1949. Descrizione di due specie nuove cavernícole di Campodeidae (Insecta Diplura) della regione del Monte Tauro. *Bolletino del Laboratorio d'Entomologia agraria in Portici* 9: 27-31.

Sket B. 2012. Diversity patterns in the Dinaric Karst (pp. 228-238). *In:* Culver D.C., White W.B. (eds). Encyclopaedia of Caves. *Elsevier Academic Press, Oxford, UK,* 945 pp.

Sket B., Paragamian K., Trontelj P. 2004. A census of the obligate subterranean fauna of the Balkan Peninsula. (pp. 309-322). *In:* Griffiths H.I., Krystufek B., Reed J.M. (eds). Balkan Biodiversity. *Kluwer Academic Publishers, Dordrecht, the Netherlands*, 357 pp.

Stoev P. 2001. A synopsis of the Bulgarian cave centipedes (Chilopoda). *Arthropoda Selecta* 10(1): 31-54.

Trontelj P., Douady C.J., Fišer C., Gibert J., Gorički Š., LeféBure T., Sket B., Zakšek V. 2009. A molecular test for cryptic diversity in ground water: how large are the ranges of macro-stygobionts? *Freshwater Biology* 54(4): 727-744.

Verhoeff K.W. 1897. Über Diplopoden aus Bosnien, Herzegowina und Dalmatien. I. Theil: Polydesmidae. *Archiv für Naturgeschichte* 63(1): 139-146.

Westwood J.O. 1842. Description of a new genus of apterous hexapod insects found near London. *The Annals and magazine of natural history* 10: 71.

Wygodzinsky P. 1944. Contribuiçao ao conhecimento da familia Campodeidae (Entotrophi, Insecta) do Mexico. *Annales de la Escuela Nacional de Ciencias Biológicas* 3: 367-404.

Zagmajster M., Eme D., Fišer C., Galassi D., Marmonier P., Stoch F., Cornu J.-F., Malard F. 2014. Geographic variation in range size and beta diversity of groundwater crustaceans: insights from habitats with low thermal seasonality: range size and beta diversity in non-seasonal habitats. *Global Ecology and Biogeography* 23: 1135-1145.

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Extraordinary claims require extraordinary evidence: on the taxonomic identity of *Phalotris cerradensis* Silveira, 2020

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Abstract: *Phalotris* Cope, 1862 is a fossorial dipsadid snake genus that encompasses 15 species, distributed mainly in open areas from Northeastern Brazil to Southern Argentina. Some of its species are known from small series, and there is little to no knowledge on their morphological variation and species delimitations. In this work, we analyze the taxonomic status of *Phalotris cerradensis* Silveira, 2020, a recently described species known from a single specimen, and provide evidence for its synonymy with *Phalotris concolor* Ferrarezzi, 1993.

Keywords: Elapomorphini - Neotropical - Synonym - Systematics.

INTRODUCTION

Phalotris Cope, 1862 is a speciose genus of Neotropical dipsadid snakes, with 15 small to medium sized species (< 1 m) that are widely distributed in open areas from Northeastern Brazil to Southern Argentina (Ferrarezzi, 1993; Costa & Bérnils, 2018). Together with the genera *Apostolepis* Cope, 1862, *Coronelaps* Lema & Deiques, 2010, *Elapomorphus* Wiegmann, 1843, they constitute the Elapomorphini Jan, 1862 tribe, a clade of approximately 50 cryptozoic and fossorial species (Ferrarezzi, 1993; Zaher, 1999; Zaher *et al.,* 2009; Grazziotin *et al.,* 2012; Entiauspe-Neto *et al.,* 2019). The Elapomorphini tribe can be diagnosed on the basis of a short dentigerous dentary teeth process, U-shaped fronto-parietal suture, two or less pterygoid palatine teeth, usually six or less supralabial scales, and an entire nasal plate (Ferrarezzi, 1993; Zaher, 1999; Zaher *et al.,* 2009). The morphological diagnosis of *Phalotris* is based on a single (fused) prefrontal scale, separated from two internasals (Ferrarezzi, 1993).

As in other Elapomorphini genera, *Phalotris* has been long subjected to taxonomic controversy. Some of its species are known based on a single or a small series of specimens (e.g. *Phalotris concolor* Ferrarezzi, 1994 [n = 4], *Phalotris multipunctatus* Ferrarezzi, 1994 [n = 4], *Phalotris nigrilatus* Ferrarezzi, 1993 [n = 15], *Phalotris normanscotti* Cabral & Cacciali, 2015 [n = 3]) even after long time periods since their description (Atkinson *et al.,* 2019; Cacciali *et al.,* 2020); others have had conflicting views among authors regarding their delimitations and validity (e.g. *Phalotris bilineatus* Duméril, Bibrón & Duméril, 1852; *Phalotris lemniscatus* Duméril, Bibrón & Duméril, 1852; *Phalotris reticulatus* Peters, 1860), with various interpretations (see Lema, 1979; Ferrarezzi, 1993).

Ferrarezzi (1994) described *Phalotris concolor* on the basis of an adult female specimen (IBSP 55018) from Cristália, Minas Gerais state, in the Cerrado of Southeastern Brazil. It was distinguished from its congeners by a suite of morphological characters, and said to be "distanced" from others due to a higher number of ventral scales. It remained known from its holotype (and subsequently, lost in the Instituto Butantan fire of 2010), until Moura *et al.* (2013) reported its rediscovery, based on two specimens from Brasilândia de Minas and Urucuia, both at Cerrado localities in Minas Gerais,

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Southeastern Brazil, while also providing a detailed redescription and an emended diagnosis. Freitas *et al.* (2016) reported its first record to Bahia, Northeastern Brazil, based on a specimen from the Cerrado of Cocos, close to the border with Minas Gerais.

Recently, Silveira (2020) described *Phalotris cerradensis*, on the basis of the same specimen reported by Freitas *et al.* (2016), a subadult male individual (CHUNB 51553) from Cocos, Bahia, Northeastern Brazil, providing only brief comments on its morphology and allocating it in the *Phalotris nasutus* species group, together with *P. concolor* Ferrarezzi, 1993; *P. labiomaculatus* Lema, 2002; *P. lativittatus* Ferrarezzi, 1994; *P. nasutus* Gomes, 1915; and *P. nigrilatus* Ferrarezzi, 1994. Silveira (2020) also states *P. cerradensis* is "phenotypically similar" to *P. concolor*. In this work, we reanalyze the holotype of *P. cerradensis*, and review its taxonomic status.

MATERIAL AND METHODS

We examined a total of 38 *Phalotris* specimens from the following collections: Coleção Herpetológica Universidade de Brasília (CHUNB), Coleção Herpetológica Universidade Federal do Rio Grande (CHFURG), Coleção Herpetológica Museu de Ciências e Tecnologia PUCRS (MCP), Fundacíon Miguel Lilo (FML), Museo Nacional de Historia Natural de Paraguay (MHNP), Museu de Zoologia João Moojen de Oliveira (MZUFV), Coleção Zoológica Universidade Federal de Santa Maria (ZUFSM). A list of the examined material is provided in Appendix. The geographic distribution of the *Phalotris nasutus* group was inferred based on records from Ferrarezzi (1994), Freitas *et al*. (2016), Nogueira *et al.* (2019), and Cacciali *et al*. (2020).

An emended diagnosis, as well as meristic and morphometric characters followed the nomenclature used by Entiauspe-Neto *et al.* (2020) for *Apostolepis*, as follows: head length, measured from the center of rostral to the corner of mouth; head width, measured at the corner of mouth; snout-vent length, ventrally measured from the center of rostral to the posterior margin of cloacal scale; tail length, measured from the posterior margin of cloacal scale to the terminal scale. Head and tail measurements were taken with a dial caliper to the nearest 0.01 mm; for others, a flexible ruler was used. Scale counts follow Dowling (1951). Sex was determined through a subcaudal incision.

RESULTS

Upon examination of the holotype of *P. cerradensis*, it becomes evident that the correct specimen number is in fact "CHUNB 51553", and not "CHUNB 52553", as stated in its description. According to Silveira (2020), the type specimen differs from its congeners by the following characters: a prominent rostral scale (projected), but with a rounded apex; presence of contact between the rostral and the prefrontal, which separates the pair of internasals, prefrontal with a more pronounced angle (evident) on its anterior edge; 1+1 temporals, fifth labial (supralabial) separated from the parietal for its anterior temporal; the number of ventral scales relatively high (202 in a male); the number of subcaudal scales also relatively high (36 pairs in a male); dorsum with uniform coloration, yellow in preservative and reddish-orange in life (with a vestigial dark vertebral stripe); venter with clear (sic) immaculate coloration, cream in preservative, with black blotches on chinshields; a pronounced and narrow anterior nuchal white collar, one to two wide dorsal at vertebral and paravertebral rows (smaller than its black nuchal collar); a pronounced and wide black nuchal collar, three to five wide dorsals at vertebral and paravertebral rows (Silveira, 2020: 54).

Furthermore, Silveira (2020) provides a comparison of *P. cerradensis* with *P. concolor* (characters in parentheses), distinguishing it from the latter by the presence of black dorsal and lateral head surfaces, with white supralabial blotches (versus darker color of dorsal surface of the head, pale or cream supralabial surfaces); white nuchal collar that is narrower than black nuchal collar (versus white nuchal collar broader than black nuchal collar).

Both characters, head coloration and nuchal collar size, are also regarded as highly polymorphic in Elapomorphini species (see Entiauspe-Neto *et al.,* 2020). There is only minor difference in the extent of nuchal collars over dorsal scale rows in *P. cerradensis* (white nuchal collar 1-2 scales wide, black nuchal collar 3-5 scales wide) and *P. concolor* (white nuchal collar 2-3 scales wide, black nuchal collar 1-3 scales wide).

The holotype of *Phalotris cerradensis* shares several similarities with the known specimens of *P. concolor* (Figs 1, 2): (1) rostral projected in lateral view, rounded in dorsal view; (2) temporals 1+1, fifth supralabial separated from parietal by anterior temporal; (3) a high number of ventrals in males (202 in the male *P. cerradensis*, 212 in the male *P. concolor*); (4) a high number of subcaudals in males (36 pairs in the male *P. cerradensis*, 34 in the male *P. concolor*); (5) orange or red dorsal coloration in life; (6) immaculate cream venter.

Both type localities (Cristália and Cocos) are situated within the Cerrado biome, and *Phalotris concolor* has been recorded close to *P. cerradensis* (Fig. 3). The only remaining difference is in coloration characters that are generally highly variable in these snakes. It should also be noted that *P. concolor* is known from fewer than 5 individuals, and these differences likely constitute the extremes of morphological variation for these characters (Table 1). Considering the lack of specific diagnostic characters and a significant overlap in morphology, we propose that *P. cerradensis* should be considered as a junior synonym of *P. concolor*. *Phalotris concolor* can be diagnosed based on (1) 15-15-15 dorsal scales; (2)

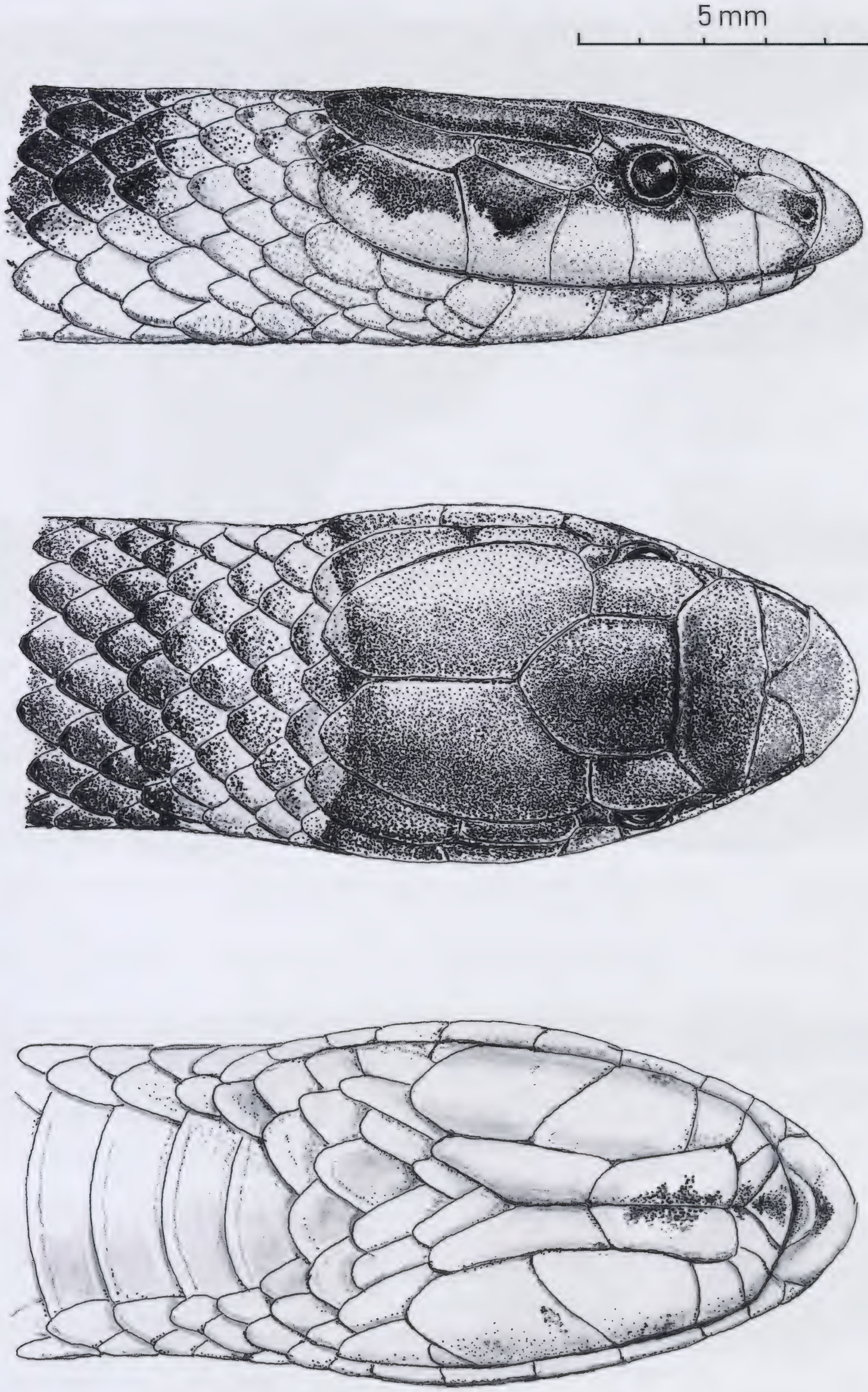

Fig. 1. Scalation of *Phalotris concolor* (MZUFV 1870).

Fig. 2. Morphological variation of *Phalotris concolor*. Top: Juvenile male (CHUNB 51553, former holotype of *P. cerradensis*); Middle: Adult male (MZUFV 1890); Bottom: Adult female (MZUFV 1870).

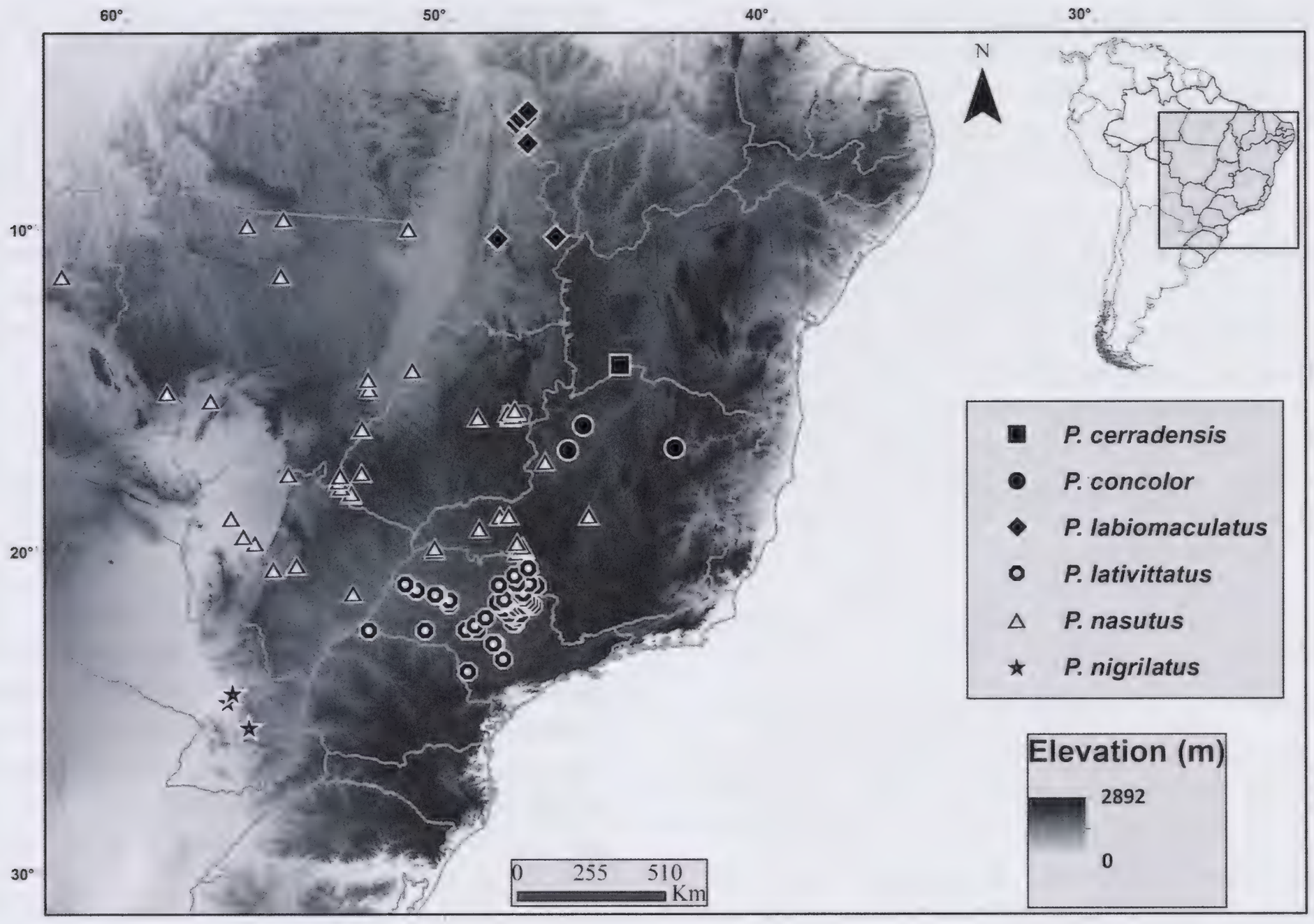

Fig. 3. Geographic distribution of the *Phalotris nasutus* species group.

Table 1. Morphological variation of *Phalotris concolor*. Measurements are given in mm. Data from [1]Ferrarezzi (1994); [2]Moura *et al.* (2013).

Characters	**IBSP 55018 (holotype of *P. concolor*)[1]**	**CHUNB 51553 (holotype of *P. cerradensis*)**	**MZUFV 1870[2]**	**MZUFV 1890[2]**
Age, sex	Adult female	Juvenile male	Adult female	Adult male
Head length	15	8.4	8.8	14.2
Head width	8	4.6	5.2	7.3
Tail length	43	19.1	23	60
Total length	550	203	322	582
Snout-vent length	507	184	299	522
Ventrals	224	202	220	212
Subcaudals	29	36	28	34
Supralabials	6, 2-3 in contact with orbit	6, 2-3 in contact with orbit	6, 2-3 in contact with orbit	6, 2-3 in contact with orbit
Infralabials	7, 1-4 in contact with anterior chinshields	7, 1-4 in contact with anterior chinshields	7, 1-4 in contact with anterior chinshields	7, 1-4 in contact with anterior chinshields
Temporals	1+1	1+1	1+1	1+1
Dorsal pattern	Uniformly red	Uniformly reddish orange	Uniformly orange	Uniformly reddish orange
Ventral color	Uniformly cream	Uniformly cream	Uniformly cream	Uniformly cream
White nuchal collar width	2-3 dorsal scale rows wide	1-2 dorsal scale rows wide	3 scale rows wide	2-3 dorsal scale rows wide
Black nuchal collar width	1-2 dorsal scale rows wide	3-5 dorsal scale rows wide	1-2 dorsal scale rows wide	1-2 dorsal scale rows wide

preocular present, contacting nasal; (3) loreal absent; (4) temporals 1+1 (rarely 1+1+1); (5) supralabials six, 2nd-3rd in contact with orbit; (6) infralabials seven, 1st-4th in contact with anterior chinshields; (7) ventrals 202-224 (220-224 in females, 202-212 in males); (8) subcaudals 28-36 (28-29 in females, 34-36 in males); (9) dorsal pattern uniformly red or orange, vertebral stripe, if present, vestigial; (10) ventral pattern uniformly cream, head and gular region white, diffuse black pigmentation on infralabials, chinshield, gulars, and symphisal; (11) white nuchal collar covering 1-3 rows, black nuchal collar covering 1-5 rows; (12) supralabial blotch large or medium, covering four to six supralabials; (13) SVL 184-522 mm, TL 23-60 mm.

DISCUSSION

The number of *Phalotris* species is herein reduced to 14. Recent rediscoveries (e.g. *P. nigrilatus*, Cacciali *et al.,* 2007, 2020; *P. concolor,* Moura *et al.,* 2013; *Phalotris multipunctatus,* Atkinson *et al.,* 2018) have highlighted that these secretive snakes may go undetected for long periods, even in historically well-sampled areas. More than that, these findings particularly call attention to the slight variations in meristic, morphometric and color pattern characters, even in specimens collected in the same locality. Not by chance, *P. lemniscatus*, the congener whose morphology has been most extensively studied (> 300 specimens), is the species that exhibits chromatic variations the most, with at least 8 recognizable patterns and some intermediate specimens between them (Noronha, 2012). If we consider the putatively diagnostic characteristics between *P. cerradensis* and *P. concolor* (head coloration and nuchal collar size) in the light of the variation of *P. lemniscatus*, it is possible to notice that both are very fragile. While the head color can vary from black to light brown in *P. lemniscatus*, the nuchal collar size is widely variable and may even be absent in many specimens (Noronha, 2012; this study). In addition, the same pattern variation in the nuchal collar has already been pointed out for more than one species of the genus *Apostolepis*, which suggests that this characteristic is highly variable not only in *Phalotris*, but possibly in Elapomorphini as a whole (Ferrarezzi *et al.,* 2005; Entiauspe-Neto *et al.,* 2020).

The most surprising feature in Silveira's (2020) paper, however, is that it contemplates exactly the combination of two factors that have generated numerous taxonomic problems in Elapomorphini throughout history: poor diagnoses based on a single specimen. This practice is obviously not exclusive to this group of snakes, and its potential negative consequences have been reported by different authors (e.g. Cruz-da-Silva *et al.,* 2018; Palacios-Aguilar & García-Vázquez, 2020). However, possibly due to the difficulty in obtaining large series of specimens, together with the high chromatic variability, this practice has become frequent in Elapomorphini (Lema, 2004a, b; Lema & Renner, 2011). This problem was addressed indirectly by Ferrarezzi *et al.* (2005), but Entiauspe-Neto *et al.* (2019) clearly exposed this point of view through direct association between single-based descriptions and subsequent synonymizations, and warned: "*We urge our fellow authors not to commit taxonomic malpractice and to carefully generate, rethink and analyze their data,* ***providing compelling evidence for their claims***" (our bold). Currently, the snake's systematics has evolved in order to increasingly combine sources of evidence to support taxonomic decisions (e.g. cranial osteology, muscular, glandular and hemipenial morphology, and different molecular frameworks) and minimize nomenclatural instabilities. We argue that, while many of these sources of evidence do not yet exist in the scientific literature for much of the species of Elapomorphini, this should not be seen as a reason to continue a tortuous cycle of rudimentary descriptions. On the contrary, it should be seen as an excellent opportunity to put into practice a more robust taxonomy and really provide useful information regarding the diversity and evolutionary relationships of this elusive neotropical snake lineage.

Phalotris concolor is a poorly known species, known from four specimens, and restricted to the Cerrado open areas of the Espinhaço Range, a narrow mountain formation between the states of Minas Gerais and Bahia. There is no available information on its populational trends or conservation, and very little is known about its natural history. We suggest that further fieldwork on the Espinhaço Range should uncover new specimens, and help enrich the knowledge on the variation of this elusive species.

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REFERENCES

Atkinson K., Smith P., Dickens J.K., Lee-Zuck C. 2018. Rediscovery of the 'lost' snake *Phalotris multipunctatus*

(Serpentes: Dipsadidae) in Paraguay with behavioral notes and reference to the importance of Rancho Laguna Blanca for its conservation. *Current Herpetology* 37: 75-80.

Cabral H., Cacciali P. 2015. A new species of *Phalotris* (Serpentes: Dipsadidae) from the Paraguayan Chaco. *Herpetologica* 71: 72-77.

Cacciali P., Carreira S., Scott N. 2007. Redescription of *Phalotris nigrilatus* Ferrarezzi, 1993 (Serpentes: Colubridae: Xenodontinae). *Herpetologica* 63: 552-559.

Cacciali P., Mee G., Laing A.P., Krause D., Mclaughlin C., Montgomery R., Smith P. 2020. Morphological Re-Examination of the Endemic Paraguayan Snake *Phalotris nigrilatus* Ferrarezzi, 1993 (Serpentes: Colubridae: Elapomorphini), with Notes on Its Ecology and Conservation Status. *Current Herpetology* 39: 28-37.

Costa H.C., Bérnils R.S. 2018. Répteis do Brasil e suas Unidades Federativas: Lista de espécies. *Herpetologia Brasileira* 7: 11-57.

Cruz-da-Silva R.C., Freitas M.A., Abegg A.D. 2018. A remarkable specimen of the genus *Anilius* (Serpentes: Aniliidae): rare colour aberration or a new species? *Herpetology Notes* 11: 161-165.

Dowling H.G. 1951. A proposed standard system of counting ventrals in snakes. *British Journal of Herpetology* 1: 97-99.

Entiauspe-Neto O.M., Sena A., Tiutenko A., Loebmann D. 2019. Taxonomic status of *Apostolepis barrioi* Lema, 1978, with comments on the taxonomic instability of *Apostolepis* Cope, 1862 (Serpentes, Dipsadidae). *Zookeys* 841: 71-78.

Entiauspe-Neto O.M., Guedes T.B., Loebmann D., Lema T. 2020. Taxonomic status of two simultaneously described *Apostolepis* Cope, 1862 species (Dipsadidae: Elapomorphini) from Caatinga Enclaves Moist Forests, Brazil. *Journal of Herpetology* 54: 225-234.

Ferrarezzi H. 1993. Sistemática Filogenética de *Elapomorphus*, *Phalotris* e *Apostolepis* (Serpentes: Colubridae: Xenodontinae). (Unpublished Master's Dissertation), *Universidade de São Paulo, Brazil,* 277 pp.

Ferrarezzi H. 1994 (1993). Nota sobre o gênero *Phalotris* com revisão do grupo *nasutus* e descrição de três novas espécies (Serpentes, Colubridae, Xenodontinae). *Memórias do Instituto Butantan* 55: 21-38.

Ferrarezzi H., Barbo F.E., Albuquerque C.E. 2005. Phylogenetic relationships of a new species of *Apostolepis* from Brazilian Cerrado with notes on the *assimilis* group (Serpentes: Colubridae: Xenodontinae: Elapomorphini). *Papéis avulsos de Zoologia* 45: 215-229.

Freitas M.A., Colli G.R., Entiauspe-Neto O.M., Trinchão L., Araújo D., Lima T.O., França D.P.F., Gaiga R., Dias P. 2016. Snakes of Cerrado localities in western Bahia, Brazil. *Check List* 12: 1896.

Grazziotin F.G., Zaher H., Murphy R.W., Schrocchi G., Benavides M.A., Zhang Y.P., Bonatto S.L. 2012. Molecular phylogeny of the New World Dipsadidae (Serpentes: Colubroidea): a reappraisal. *Cladistics* 28: 437-459.

Lema T. 1979. Sobre a validade dos nomes *Elapomorphus bilineatus* Duméril, Bibron and Duméril, 1854 e *E. lemniscatus* Duméril, Bibron and Duméril, 1854 (Ophidia: Colubridae). *Iheringia* 54: 77-81.

Lema T. 2004a. Description of a new species of *Apostolepis* Cope, 1861 (Serpentes, Elapomorphinae) from Brazilian Cerrado. *Acta Biologica Leopoldensia* 26: 155-160.

Lema T. 2004b. New species of *Apostolepis* Cope, 1861 from Caatinga belonging to *assimilis* group (Serpentes, Elapomorphinae). *Comunicações do Museu de Ciências e Tecnologia da PUCRS. Série zoologia* 17: 3-7.

Lema T., Rener M.F. 2011. A new species of *Apostolepis* (Serpentes, Colubridae, Elapomorphini), belonging to *assimilis* group, found in Brazilian Cerrado. *Ciência em Movimento* 13: 71-76.

Moura M.R., Costa H.C., Pirani R.M. 2013. Rediscovery of *Phalotris concolor* (Serpentes: Dipsadidae: Elapomorphini). *Zoologia (Curitiba)* 30: 430-436.

Nogueira C.C., Argôlo A.J., Arzamendia V., Azevedo J.A., Barbo F.E., Bérnils R.S., Bolocho B.E., Borges-Martins M., Brasil-Godinho M., Braz H., Buononato M.A., Cisneros-Heredia D.F., Colli G.R.C., Costa H.C., Franco F.L., Giraudo A., Gonzalez R.C., Guedes T., Hoogmoed M.S., Marques O.A.V., Montingelli G.G., Passos P., Prudente A.L.C., Rivas G.A., Sanchez P.M., Serrano F.C., Silva-Jr. N.J., Strüssmann C., Vieira-Alencar J.P.S., Zaher H., Sawaya R.J., Martins M. 2019. Atlas of Brazilian snakes: verified point-locality maps to mitigate the Wallacean shortfall in a megadiverse snake fauna. *South American Journal of Herpetology*, 14: 1-274.

Noronha F.O. 2012. Revisão taxonômica do complexo *Phalotris lemniscatus* (Duméril, Bibron et Duméril, 1854) e *Phalotris reticulatus* Peters, 1860 (Serpentes: Dipsadidae). (Unpublished Course Conclusion Thesis), *Universidade Federal do Rio Grande do Sul, Brazil*, 33 pp.

Palacios-Aguilar R., García-Vázquez U.O. 2020. A partial molecular phylogeny of *Rhadinaea* and related genera (Squamata, Dipsadidae) with comments on the generic assignment of *Rhadinaea eduardoi*. *ZooKeys* 943: 145-155.

Silveira A.L. 2020. Uma nova espécie de *Phalotris* (Serpentes, Dipsadidae) do cerrado no nordeste do Brasil. *Acta Biologica Brasiliensia* 3: 47-67.

Zaher H. 1999. Hemipenial morphology of the South American xenodontine snakes, with a proposal for a monophyletic Xenodontinae and a reappraisal of Colubrid hemipenes. *Bulletin of the American Museum of Natural History* 240: 1-168.

Zaher H., Grazziotin F.G., Cadle J.E., Murphy R.W., Moura-Leite J.C., Bonatto S.L. 2009. Molecular phylogeny of advanced snakes (Serpentes, Caenophidia) with an emphasis on the South American xenodontines: a revised classification and descriptions of new taxa. *Papéis Avulsos de Zoologia* 49: 115-153.

APPENDIX

Material examined: 38 specimens. *Phalotris concolor* (*n*=3): CHUNB 51553, holotype of *P. cerradensis*, Brazil, Bahia, Cocos. – MZUFV 1870, Brazil, Minas Gerais, Brasilândia de Minas. – MZUFV 1890, Brazil, Minas Gerais, Urucuia.
Phalotris nigrilatus (n=2): FML 0709, holotype of *P. nigrilatus,* Paraguay, San Pedro, Carumbé. – MHNP 12577 Paraguay, San Pedro, Colonia Friesland.
Phalotris labiomaculatus (n = 1): MCP 10693, holotype of *P. labiomaculatus,* Brazil, Maranhão, Porto Franco.
Phalotris lemniscatus (n = 30): ZUFSM 0736, Brazil, Rio Grande Do Sul, Caçapava do Sul. – ZUFSM 1351, Brazil, Rio Grande Do Sul, Cacequi. – MCP 14323, CHFURG 1251, 1501, Brazil, Rio Grande Do Sul, Campus da FURG, Rio Grande. –

CHFURG 766, Brazil, Rio Grande Do Sul, Cassino, Rio Grande. – CHFURG 4905, 4906, 4912, 4913, 4914, Brazil, Rio Grande Do Sul, Corredor da Barra, Rio Grande. – CHFURG 1413, 1483, 1724, Brazil, Rio Grande Do Sul, ESEC Taim. – ZUFSM 2676, Rio Grande Do Sul, Júlio de Castilhos. – CHFURG 843, Brazil, Rio Grande Do Sul, Parque São Pedro, Rio Grande. – CHFURG 934, 1110-1120, Brazil, Rio Grande Do Sul, Rio Grande. – ZUFSM 2772, Brazil, Rio Grande Do Sul, Quaraí. – CHFURG 696, Brazil, Rio Grande Do Sul, São Lourenço. – ZUFSM 2773, Brazil, Rio Grande Do Sul, Santiago.

Phalotris matogrossensis (n=1): MCP 12801, holotype of *P. matogrossensis,* Brazil, Mato Grosso, Cuiabá.

Phalotris nasutus (n = 1): MCP 15322, Brazil, Mato Grosso: U.H.E. Manso, Chapada dos Guimarães.

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Diversité des fourmis (Hymenoptera, Formicidae) dans la forêt de Yakouren (Algérie) : Estimation de la richesse, biogéographie et taxonomie

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Résumé : Nous avons échantillonné des fourmis dans la forêt de Yakouren en combinant trois méthodes : pots barber, chasse à vue et appâts alimentaires. Vingt-sept (27) taxons ont été répertoriés appartenant aux sous-familles suivantes : Myrmicinae, Formicinae et Dolichoderinae. *Camponotus alii*, *Pheidole pallidula* et *Crematogaster auberti levithorax* sont les espèces les plus abondantes. Le calcul de différents estimateurs de richesse (Chao 1, Jackknife 1 et ICE) montrent qu'il y a toujours une possibilité de rencontrer de nouvelles espèces en augmentant l'effort d'échantillonnage. La composition des peuplements de fourmis dans le massif de Yakouren révèle une faible dégradation du milieu par rapport à des relevés réalisés dans les années 1960. Le milieu souffre des actions anthropiques, dont des incendies, que subit la région depuis plusieurs décennies. Les statuts taxonomiques de *Camponotus lateralis purius* et d'*Aphaenogaster sardoa ujhelyii* sont discutés.

Mots-clés : Formicidae - échantillonnage - estimateurs - richesse - Yakouren.

Abstract : Diversity of ants (Hymenoptera, Formicidae) in Yakouren forest (Algeria) : species richness, biogeography and taxonomy.- We sampled the ants in the Yakouren forest by combining three methods : Pitfall traps, hand sampling and bait traps. Twenty-seven (27) taxa were collected from the subfamilies Myrmicinae, Formicinae and Dolichoderinae. *Camponotus alii*, *Pheidole pallidula* and *Crematogaster auberti* are the most abundant species respectively. Different estimators of richness (Chao 1, Jackknife 1 and ICE) show that it would be possible to obtain new species by increasing the sampling effort. The composition of the ant populations in the mountains of Yakouren reveals a low environmental degradation compared to surveys conducted in the 1960s. The environment suffers from anthropogenic actions, including fires, the latter for several decades. The taxonomical status of *Camponotus lateralis purius* and *Aphaenogaster sardoa ujhelyii* are discussed.

Keywords : Formicidae - sampling - estimators - richness - Yakouren.

INTRODUCTION

Dans le bassin méditerranéen, le secteur Kabylie-Numidie-Kroumirie est considéré comme un point chaud de biodiversité (*Hotspot*) (Véla & Benhouhou, 2007). Le massif forestier de Yakouren constitue un écosystème forestier important faisant partie à la région de la Kabylie qui figure parmi les aires dont le taux d'endémisme des plantes avoisine 10 % (Médail & Quézel, 1997). Avec les massifs de l'Akfadou, Yakouren représente 18 % de la surface totale de ce type d'écosystème forestier en Algérie (Messaoudène *et al*., 2007; Boudedja & Abdelhakim, 2013). Selon Véla & Benhouhou (2007), les forêts de la petite Kabylie figurent parmi les secteurs qui hébergent les endémiques les plus rares. Malheureusement, ces forêts ont connu ces dernières années des perturbations dues à plusieurs facteurs humains qui menacent cet endémisme. Selon le Bureau national des études forestières (BEF), la forêt de Beni Ghobri, à l'instar des autres forêts

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de la Kabylie, est soumise à des pratiques néfastes (élevage extensif, arrachage des espèces végétales ligneuses et herbacées, défrichement, labour illicite et incendies). Ces pratiques se sont accentuées ces dernières années et ont abouti à un processus de dégradation en chaîne du domaine forestier (érosion, déséquilibre au niveau de l'environnement) (Boudedja & Abdelhakim, 2013). Le pourcentage de surface brûlée dans la forêt de Beni Ghobri durant la période 1986-2005 atteint 86,42 % de la surface forestière totale (Meddour-Sahar, 2008). Le feu fait partie du fonctionnement des écosystèmes, toutefois, l'augmentation de leur fréquence a des impacts considérables sur la végétation, la faune, la microfaune, les sols, la déforestation, le climat et la perte de biodiversité (Triplet, 2020). Les communautés de fourmis constituent de véritables indicateurs de la biodiversité et de la santé des écosystèmes (Majer, 1983 ; Andersen *et al.*, 2004). Les relations étroites qu'entretiennent les fourmis avec leur environnement les rendent sensibles aux variations et aux perturbations de ce dernier (Majer, 1983 ; Alonso, 2000). De ce fait, l'analyse des communautés de fourmis constitue un moyen très efficace pour apprécier le degré de perturbation des habitats, d'évaluer les changements environnementaux globaux et d'estimer les niveaux de biodiversité (Ramage & Ravary, 2015). Ce groupe d'insectes présente une grande diversité d'espèces, facile à collecter et possède une grande abondance. Il est considéré comme candidat idéal en tant que groupe bio-indicateur (Majer, 1983 ; Hölldobler & Wilson, 1990).

Les premières investigations myrmécologiques dans les forêts algériennes reviennent à Cagniant (1968, 1970, 1973) qui a exploré plusieurs stations forestières et subforestières dont la forêt de Yakouren faisait partie. Le présent travail a pour objectifs : i) de déterminer le niveau de biodiversité myrmécologique au sein de ce type d'habitat, ii) d'évaluer la dégradation du milieu depuis les années 1960 par comparaison avec des observations antérieures et par ce biais, confirmer l'intérêt bioécologique des fourmis.

MATÉRIELS ET MÉTHODES

Site d'étude

La présente étude a été menée au sein du massif forestier de Yakouren (centre nord de l'Algérie ; wilaya de Tizi-Ouzou) dénommé également massif forestier de Béni Ghobri. D'une superficie de 6939 ha (Boudedja & Abdelhakim, 2013), Yakouren se présente généralement sous forme de futaie dense à sous-bois peu développé et composée de chênes mixtes : chêne afarès *Quercus afares* Pomel, chêne zéen *Q. canariensis* Wild, chêne-liège *Q. suber* L. et chêne faginé *Q. faginea* Lam. (Boudedja & Abdelhakim, 2013 ; Haddar *et al.*, 2016). L'aire d'étude choisie (WGS (84) 36.7556, 4.41384) a une superficie d'environ 4134 m^2 et présente un relief peu accidenté (5 % de pente), comprise entre 700 et 860 m d'altitude (Fig. 1). La pluviométrie annuelle est de

Fig. 1. Situation géographique du massif de Yakouren (Shorthouse, 2010).

l'ordre de 750 à 1200 mm. La flore de l'aire d'étude est composée de plusieurs espèces réparties sur 20 familles botaniques (Tab. 1), dont le chêne zéen *Q. canariensis* et le chêne faginé *Q. faginea* sont les plus abondants. Le couvert végétal global de la strate herbacée est estimé visuellement à 70 %. Quant à la couverture de la canopée, son taux est estimé de 60 % à 70 % selon le gradient proposé par Schomaker *et al.* (2007).

Echantillonnage de la myrmécofaune

L'échantillonnage des fourmis a été réalisé en combinant trois méthodes : les pots Barber, les pièges appâts et la collecte manuelle.

Un total de trente pots Barber a été installé durant les mois de juillet, août et octobre 2018 à raison de 10 pièges pour chaque mois. Ils sont disposés en deux lignes distantes de 15 m et comportant 5 pièges à intervalle de 15 m. Ces derniers sont des demi-bouteilles en matière plastique transparent (Ø : 8 cm, profondeur : 10 cm), remplies aux ¾ par de l'eau additionnée de quelques gouttes de détergent et d'alcool à 70° pour la conservation des spécimens. Chaque piège est enterré assez profondément de telle sorte que le bord supérieur soit au même niveau que la surface du sol. Les pots sont récupérés après deux jours et leur contenu est transporté au laboratoire afin de l'identifier.

Concernant le piège-appât, un total de 30 pièges contenant quatre types d'appâts (thon, biscuit, miel, graines de fenouil) ont été placés séparément sur du papier aluminium autour de chaque pot Barber à une distance de 5 m dans les quatre directions cardinales (Fig. 2). Ces pièges sont laissés en place durant deux heures. Quant à l'échantillonnage à la main, une durée d'une heure a

Tableau 1. Liste des espèces végétales et des champignons inventoriés dans la forêt de Yakouren.

Planta	**Familles**	**Espèces**
	Liliaceae	*Ruscus aculeatus* L.
		Asparagus acutifolius L.
	Aspleniaceae	*Asplenium adiantum-nigrum* L.
		Asplenium trichomanes L.
	Fagaceae	*Quercus faginea* Lam.
		Quercus canariensis Willd.
	Smilacaceae	*Smilax aspera* L.
	Oleaceae	*Phillyrea media* L.
	Rubiaceae	*Galium rotundifolium* L.
	Fabaceae	*Cytisus triflorus* Lam.
	Rosaceae	*Rubus ulmifolius* Schott
	Cyperaceae	*Carex* sp.
	Asphodelaceae	*Asphodelus microcarpus* Sarl.
	Asteraceae	*Reichardia picroides* (L.) Roth.
	Poaceae	*Brachypodium distachyon* (L.) P. Beauv.
	Euphorbiaceae	*Euphorbia* sp.
	Adoxaceae	*Viburnum tinus* L.
	Primulaceae	*Cyclamen africanum* Boissier & Reuter
	Polypodiaceae	*Polypodium vulgare* L.
	Araceae	*Arisarum vulgare* O. Targ. Tozz.
Fungi	**Familles**	**Espèces**
	Amanitaceae	*Amanita pantherina* (D.C. ex. Fr.) Quél.
	Russulaceae	*Lactarius* sp.
		Russula sp.
	Agaricaceae	*Lycoperdon* sp.
	Tricholomataceae	*Tricholoma ustaloides* Romagn.

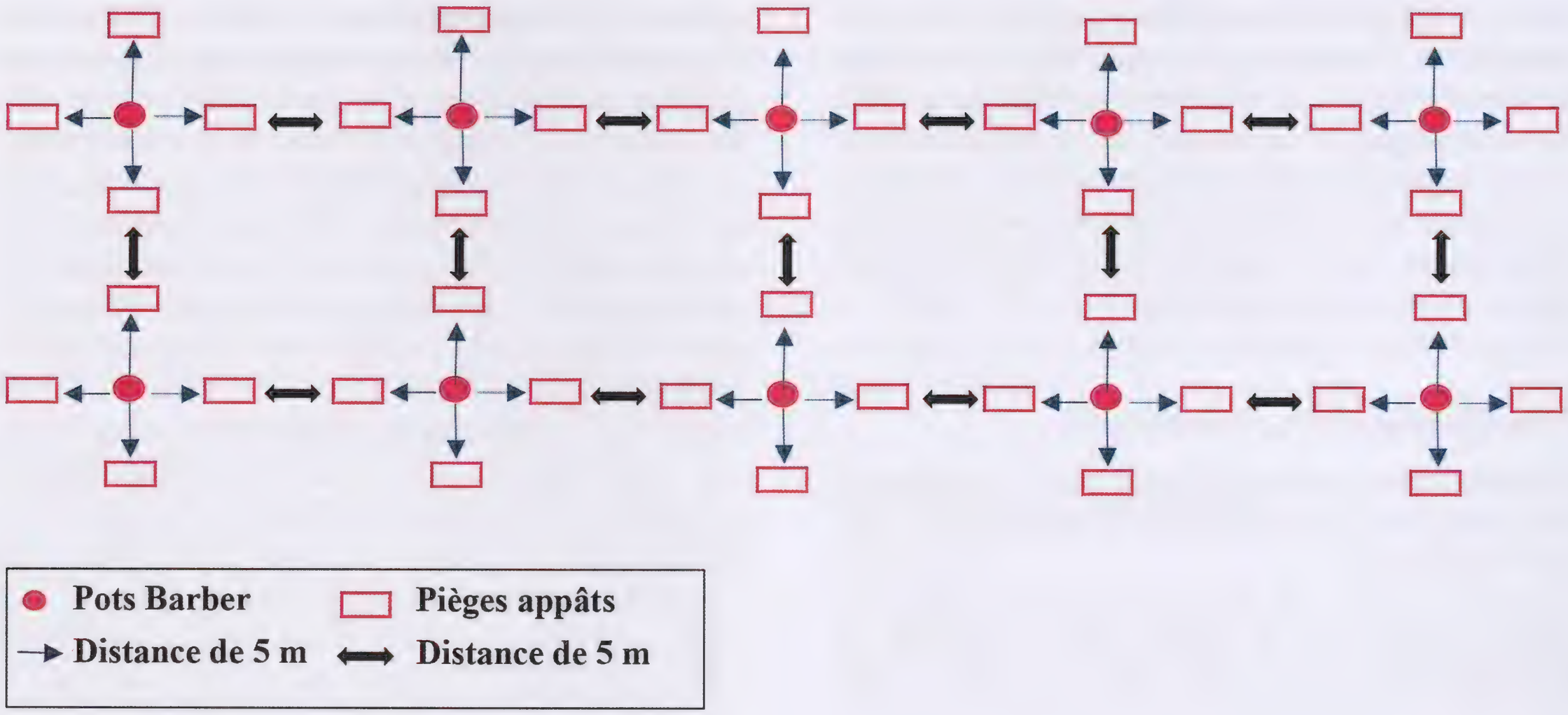

Fig. 2. Plan d'échantillonnage des fourmis dans la forêt de Yakouren.

été fixée pour la prospection et la chasse des spécimens de fourmis sous les pierres, dans les branches mortes, sous les écorces ainsi que les troncs des arbres et dans les glands tombés.

Pour tous les pièges utilisés, les spécimens récoltés sont conservés dans de l'alcool éthylique à 70°. L'identification est réalisée en utilisant les clés de Cagniant (1996a, b, 2005), Cagniant & Espadaler (1997a, b) et Barech *et al*. (2017). Des spécimens de références sont déposés dans les collections entomologiques du Département des Sciences Agronomiques de l'Université de M'sila et celui du Laboratoire PSEMRVC, Département de Biologie Animale et Végétale à l'Université Mouloud Mammeri de Tizi Ouzou.

Analyse des données

Etant donné que les fourmis sont des insectes sociaux, nous avons utilisé l'occurrence (données de présence/ absence) au lieu du nombre absolu d'individus en accord avec Wang *et al*. (2001), Longino *et al*. (2002), Martelli *et al*. (2004), Gotelli *et al*. (2011) et Kasseney *et al*. (2019). Nous avons regroupé les données d'incidences des fourmis obtenues par l'utilisation des trois méthodes de piégeage afin d'estimer la richesse en fourmis dans la forêt de Yakouren. Il faut noter que suite à de fortes pluies pendant le mois d'octobre 2018, le contenu des 10 pots installés dans la forêt a débordé; par conséquent, nous avons éliminé les résultats nuls de ces relevés afin de faciliter l'exploitation statistique. L'évaluation de l'effort de capture est obtenue par le calcul des estimateurs non paramétriques de diversité (Chao 1, Jacknife 1 et ICE) en utilisant le logiciel EstimateS Version 9.1.0 (Colwell, 2013). Ces estimateurs permettent de calculer le nombre d'espèces cumulées observées et attendues dans le site d'étude avec une randomisation de 100.

Majer (1983) et Longino (2000) suggèrent certains paramètres (indices écologiques) pour les fourmis qui peuvent être utilisés comme bio-indicateurs. Parmi ces indices, nous avons utilisé la richesse spécifique (S), l'abondance relative (AR), l'indice de diversité de Shannon (H), l'indice de diversité de Simpson (1–D) et l'indice d'Equitabilité de Pielou (J). Concernant l'indice de diversité de Shannon, ses valeurs varient de 0, dans le cas où la communauté n'est composée que d'une seule espèce, à 4,5 ou 5 bits/individu pour les communautés les plus diversifiées (Faurie *et al*., 2003). Quant à l'indice de diversité de Simpson, il varie de 0 à 1. Une valeur proche de 1 indique une diversité élevée.

Ces paramètres ont été analysés avec le logiciel PAST (PAleontological STatistics) Version 3.25 (Hammer *et al*., 2001).

Pour la fréquence d'occurrence, nous distinguerons des groupes d'espèces en fonction de leurs valeurs telles que données par Bigot & Bodot (1973):

- Les espèces constantes sont présentes dans 50 % ou plus des relevés effectués dans une même communauté, ($F \geq 50$ %)
- Les espèces accessoires présentes dans 25 à 49 % des prélèvements, ($25 \leq F < 49$ %)
- Les espèces accidentelles dont la fréquence est inférieure à 25 %, ($10 \leq F < 24$ %)
- Les espèces très accidentelles que nous qualifierons de sporadiques dont F est inférieur à 10 %.

Afin de déterminer l'efficacité (l'apport) de capture de chaque méthode d'échantillonnage utilisée dans la forêt de Yakouren, nous avons opté pour l'analyse de la

variance à un seul facteur après vérification de la normalité des données (Test de Shapiro-Wilk) avec le logiciel Statistica Version 8 (Statsoft Inc., 2012). Par ailleurs, un test HSD Tukey de structuration de moyennes a été réalisé pour une comparaison des moyennes par paire afin de voir s'il y a une différence entre méthodes de chasse des fourmis en utilisant le logiciel Past V.3.25 (Hammer *et al*., 2001).

RÉSULTATS

Composition des peuplements myrmécologiques

Richesse spécifique

L'échantillonnage mené dans la forêt de Yakouren nous a permis de récolter 2041 spécimens de 27 espèces de fourmis représentant 14 genres et 3 sous-familles (Tab. 2). Les Myrmicines (16 espèces) et les Formicines (10 espèces) sont les plus abondantes avec respectivement 59,3 % et 37 %. Les Dolichoderines contribuent avec une seule espèce, soit un taux de 3,7 %. Les genres *Aphaenogaster* et *Temnothorax* sont les mieux représentés avec quatre espèces pour chacun. La distribution biogéographique des fourmis rencontrées dans la forêt de Yakouren fait apparaître 19 espèces maghrébines, 3 espèces holoméditerranéennes, 2 ibéro-maghrébines, 2 paléarctiques et une espèce endémique algérienne.

Fréquence d'occurrence

Les résultats de la fréquence d'occurrence révèlent que *Pheidole pallidula* (20 occurrences) et *Camponotus alii* (17 occurrences) sont les plus fréquemment rencontrées (espèces constantes) dans les pièges (toutes méthodes confondues), présentant des fréquences d'occurrence égales à 58,8 % et 50,0 % respectivement (Tab. 3). *Crematogaster scutellaris algirica* (16 occurrences) qui est une espèce arboricole accessoire est présente dans 47,1 % des relevés. *Cataglyphis viaticus*, *Plagiolepis maura* et *Tetramorium biskrense* se montrent accidentelles, ce sont des espèces de lieux découverts, de même pour *Aphaenogaster mauritanica*, *Crematogaster auberti*, *C. laestrygon normandi* et *Solenopsis occipitalis*. Le reste des espèces appartient à la catégorie sporadique ou très accidentelle avec des fréquences variant entre 2,9 et 8,8 %.

Diversité du peuplement

L'indice de diversité de Shannon calculé pour les fourmis de la forêt de Yakouren est égal à 2,82 bits, celui de Simpson est de 0,92 et l'indice d'équitabilité de Pielou est égal à 0,86 (Tab. 4).

Comparaison des méthodes d'échantillonnage

La présence de fourmis dans les relevés effectués diffère selon le type de piège utilisé. Le test ANOVA à un seul facteur (One way ANOVA) a révélé une différence hautement significative entre les trois méthodes utilisées (F=7,554, P=0,001003). Le test de Tukey's nous montre que la différence est hautement significative entre les pièges appâts et les pots Barber (p=0,001484) ainsi qu'avec les pots Barber et la récolte manuelle (p=0,01028). Ces deux dernières techniques ont permis la capture du plus grand nombre d'espèces (22 et 18 respectivement). La capture à la main a apporté 8 espèces de plus par rapport aux pots Barber. Les pièges appâts, quant à eux, n'ont permis que la récolte de 5 espèces qui ont déjà été capturées manuellement ou par les pots. On notera que *A. canescens, A. crocea,* et *C. auberti levithorax* ont été piégées sur un aliment protéique (le thon), alors que *P. maura* et *P. pallidula* l'ont été sur un aliment sucré.

Estimation de la richesse

Les indices de Chao 1, Jackknife 1 et l'ICE prévoient des richesses spécifiques supérieures à la richesse observée (Sobs = 27) obtenue par les différentes méthodes d'échantillonnage (Tab. 5) soient (ICE = 34,63 ± 0,02, Chao 1 = 40,39 ± 12,36, Jack 1 = 35,74 ± 4,89). Cela signifie, au regard des 27 espèces rencontrées, qu'il resterait en moyenne 8 à 9 espèces de fourmis à découvrir dans le site par rapport à l'ICE et au Jackknife 1, et 14 espèces par rapport à Chao 1. Le taux de complétude de l'inventaire calculé sur la base de la moyenne de ces trois estimateurs est de 73 %, ce qui suggère qu'environ trois quart des espèces ont été inventoriées. L'insuffisance de l'effort d'échantillonnage effectué dans la forêt est confirmée par la croissance de la courbe d'accumulation des espèces (Sobs) et sa divergence avec celles des estimateurs choisis (Fig. 3).

Notes taxonomiques

***Camponotus lateralis purius* Santschi, 1929**

Cette sous-espèce est réhabilitée suivant sa première signalisation en 1929 par Santschi à Alger. Elle se distingue de *C. lateralis* type de Provence par la coloration rouge clair du corps et des appendices et le gastre brun noir. Récemment, Seifert (2019) dans une révision taxonomique des *Camponotus* du groupe *lateralis* d'Europe, d'Asie Mineure et du Caucase considère que la sous-espèce *Camponotus lateralis purius* n'est qu'un synonyme de *Camponotus lateralis*. Seules deux ouvrières (syntypes de l'Algérie-Alger: CASENT09111698, CASENT0911699), déposées dans le Muséum d'Histoire Naturelle de Bâle – Suisse (NHMB), ont été examinées. Selon l'un de nous (HC) *C. lateralis* est variable au Maghreb, en particulier au Maroc. Comme pour toutes les espèces arboricoles, cet habitat les expose davantage aux variations de l'environnement au cours de leur développement que celles vivant sous terre. En conséquence, les facteurs épigénétiques sont plus sensibilisés. Nous retenons la ssp. *purius* comme une entité géographique, désignant les populations du Maghreb. Il en est de même pour les différents trinômes cités ici.

***Aphaenogaster sardoa ujhelyii* Szabó, 1910**

Selon Bolton (2020), cette sous-espèce de Tunisie est érigée en bonne espèce par Szabó (1910). Il est vrai qu'il y a de petites différences entre le *sardoa* typique et celui d'Afrique du Nord. Selon Szabó (1910), *A. ujhelyii* se rapproche le plus de *A. sardoa* Mayr, 1853, mais sa taille est plus faible, sa sculpture plus fine, le thorax plus grêle, et la partie antérieure du mésonotum plus élevée que le pronotum, ce qui n'est pas le cas chez *A. sardoa*. Pour l'un de nous (HC), ces arguments ne sont pas suffisants pour l'ériger en bonne espèce en accord avec Santschi (1933) qui la considère comme variété. De ce fait, nous considérons cette fourmi comme une sous-espèce de *A. sardoa*.

Tableau 2. Inventaire, abondances et occurrences des fourmis récoltées par les différentes méthodes d'échantillonnage. Pour la distribution, nous l'exposons au niveau de l'espèce.

Sous-familles	Espèces et sous-espèces	P B		C M		P A		D
Dolichoderinae (3,7 %)	*Tapinoma magnum* Mayr, 1861	(0)	0	(7)	1	(0)	0	H
Formicinae (37,0 %)	*Camponotus alii* Forel, 1890	(643)	16	(11)	1	(0)	0	M
	Camponotus lateralis purius Santschi, 1929	(2)	2	(1)	1	(0)	0	M
	Camponotus ruber Emery, 1925	(4)	2	(0)	0	(0)	0	M
	Colobopsis truncatus (Spinola, 1808)	(1)	1	(0)	0	(0)	0	P
	Lepisiota frauenfeldi atlantis Santschi, 1917	(0)	0	(1)	1	(0)	0	M
	Cataglyphis viaticus (Fabricius, 1787)	(49)	7	(1)	1	(0)	0	M
	Lasius grandis Forel, 1909	(0)	0	(68)	1	(0)	0	H
	Lasius barbarus Santschi, 1931	(0)	0	(27)	1	(0)	0	M
	Plagiolepis maura Santschi, 1920	(20)	5	(2)	1	(1)	1	M
	Plagiolepis barbara Santschi, 1911	(4)	2	(42)	1	(0)	0	M
Myrmicinae (59,3 %)	*Aphaenogaster canescens* Emery, 1895	(0)	0	(18)	1	(25)	2	E
	Aphaenogaster crocea André, 1881	(0)	0	(3)	1	(3)	2	I
	Aphaenogaster mauritanica Dalla Torre, 1893	(18)	3	(1)	1	(0)	0	M
	Aphaenogaster sardoa ujhelyii Szabó 1910	(3)	1	(0)	0	(0)	0	M
	Crematogaster auberti levithorax Forel, 1902	(176)	2	(33)	2	(2)	1	M
	Crematogaster laestrygon normandi Santschi, 1921	(32)	3	(16)	1	(0)	0	M
	Crematogaster scutellaris algirica (Lucas, 1849)	(117)	14	(40)	2	(0)	0	M
	Messor medioruber Santschi, 1910	(0)	0	(23)	2	(0)	0	M
	Pheidole pallidula (Nylander, 1849)	(215)	13	(8)	1	(144)	6	P
	Solenopsis occipitalis Santschi, 1911	(5)	3	(290)	1	(0)	0	M
	Temnothorax atlantis (Santschi, 1911)	(4)	3	(0)	0	(0)	0	I
	Temnothorax spinosus (Forel, 1909)	(0)	0	(47)	1	(0)	0	M
	Temnothorax recedens (Nylander, 1856)	(0)	0	(4)	1	(0)	0	H
	Temnothorax algiricus Forel, 1894	(0)	0	(1)	1	(0)	0	M
	Tetramorium biskrense Forel, 1904	(13)	7	(0)	0	(0)	0	M
	Tetramorium atlante Cagniant, 1970	(1)	1	(0)	1	(0)	0	M
Total		**(1307)**	**85**	**(644)**	**25**	**(175)**	**12**	
Richesse	**27**		**18**		**22**		**5**	

PB : Pot Barber, CM : Capture à main ; PA : Piège appât, D : Distribution biogéographique, H : Holoméditerranéenne, M : Maghrébine, P : Paléarctique, E : Endémique algérienne, I : Ibéro-maghrébine. * Les valeurs des abondances sont mises entre parenthèses

Tableau 3. Fréquences d'occurrences calculées pour les fourmis capturées par les différentes méthodes de chasse (Pots Barber, Capture manuelle et Pièges appâts)

Espèces et sous-espèces	**Pi**	**FO %**	**Catégories**	**Statut**
Tapinoma magnum Mayr, 1861	1	2,9	Sporadique	Anthropique
Camponotus alii Forel, 1890	17	50,0	Constante	Eu-forestière
Camponotus lateralis purius Santschi, 1929	3	8,8	Sporadique	Eu-forestière
Camponotus ruber Emery, 1925	2	5,9	Sporadique	Méso-forestière
Colobopsis truncatus (Spinola, 1808)	1	2,9	Sporadique	Eu-forestière
Lepisiota frauenfeldi atlantis Santschi, 1917	1	2,9	Sporadique	Anthropique
Cataglyphis viaticus (Fabricius, 1787)	8	23,5	Accidentelle	Anthropique
Lasius grandis Forel, 1909	1	2,9	Sporadique	Xérophile
Lasius barbarus Santschi, 1931	1	2,9	Sporadique	Méso-forestière
Plagiolepis maura Santschi, 1920	7	20,6	Accidentelle	Méso-forestière
Plagiolepis barbara Santschi, 1911	3	8,8	Sporadique	Méso-forestière
Aphaenogaster canescens Emery, 1895	3	8,8	Sporadique	Méso-forestière
Aphaenogaster crocea André, 1881	3	8,8	Sporadique	Eu-forestière
Aphaenogaster mauritanica Dalla Torre, 1893	4	11,8	Accidentelle	Méso-forestière
Aphaenogaster sardoa ujhelyii Szabó 1910	1	2,9	Sporadique	Méso-forestière
Crematogaster auberti levithorax Forel, 1902	5	14,7	Accidentelle	Méso-forestière
Crematogaster laestrygon normandi Santschi, 1921	4	11,8	Accidentelle	Anthropique
Crematogaster scutellaris algirica (Lucas, 1849)	16	47,1	Accessoire	Eu-forestière
Messor medioruber Santschi, 1910	2	5,9	Sporadique	Anthropique
Pheidole pallidula (Nylander, 1849)	20	58,8	Constante	Anthropique
Solenopsis occipitalis Santschi, 1911	4	11,8	Accidentelle	Milieux découverts
Temnothorax atlantis (Santschi, 1911)	3	8,8	Sporadique	Eu-forestière
Temnothorax spinosus (Forel, 1909)	1	2,9	Sporadique	Eu-forestière
Temnothorax recedens (Nylander, 1856)	1	2,9	Sporadique	Eu-forestière
Temnothorax algiricus Forel, 1894	1	2,9	Sporadique	Eu-forestière
Tetramorium biskrense Forel, 1904	7	20,6	Accidentelle	Anthropique
Tetramorium atlante Cagniant, 1970	2	5,9	Sporadique	Anthropique
	122			

FO : Fréquence d'occurrence ; **Pi :** Nombre d'apparition de l'espèce i dans toute méthode confondue

Tableau 4. Indices écologiques appliqués sur la communauté des fourmis.

Indices	Valeurs
Simpson (1-D)	0,9163
Shannon (H)	2,823
Equitabilité	0,8566

Tableau 5. Estimation de la richesse totale des fourmis.

Estimateurs	**Valeurs**	**Complétude**	**Complétude moyenne**
Richesse observée (S Mean)	27		
ICE	34,63	78 %	73 %
Chao 1	40,39	67 %	
Jacknife 1	35,74	76 %	

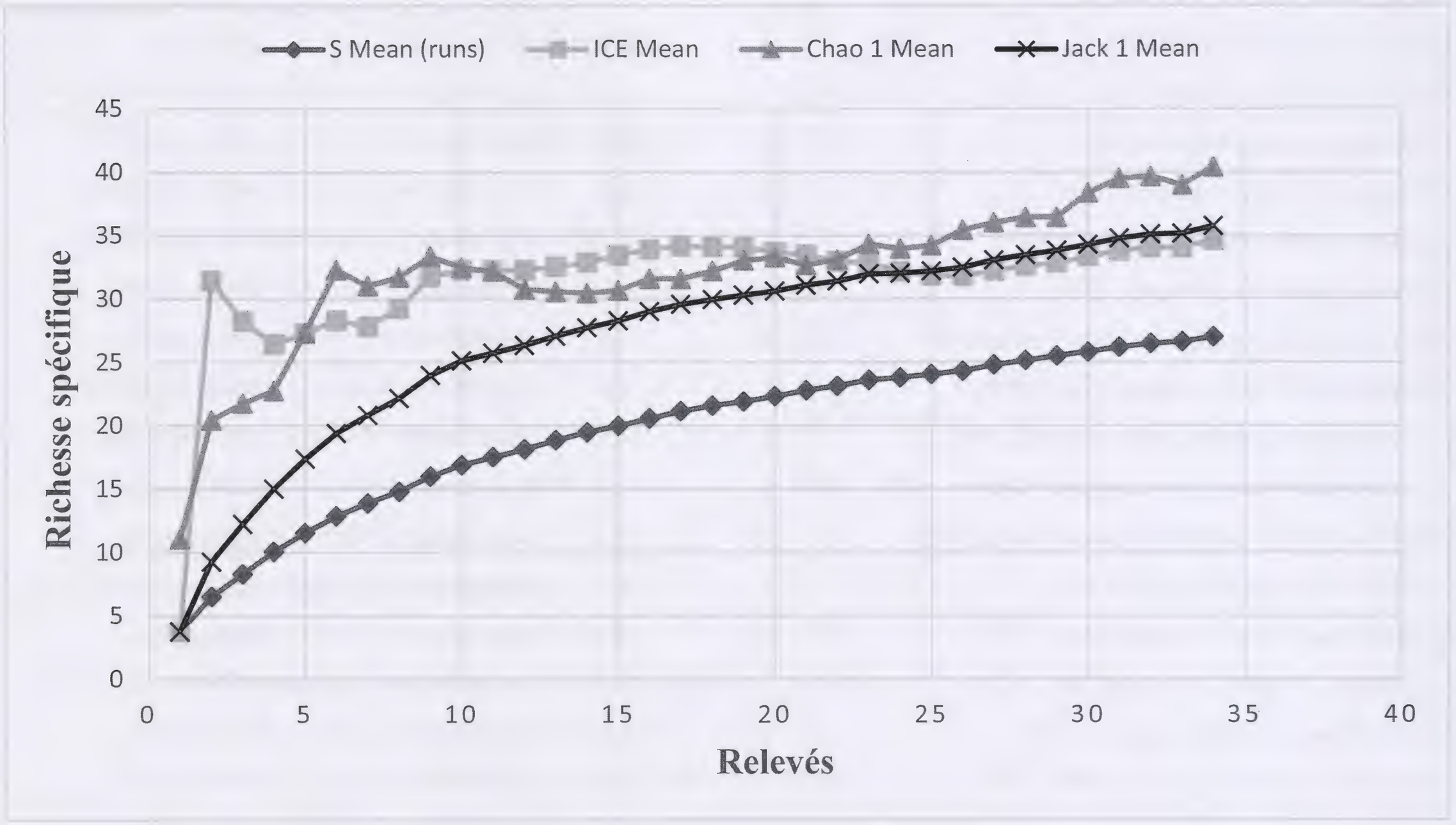

Fig. 3. Courbes d'accumulation des espèces, des estimateurs de la richesse avec toutes méthodes d'échantillonnage confondues.

DISCUSSION

La présente étude a permis le recensement de 27 espèces avec une prédominance des Myrmicines suivies par les Formicines. Les Myrmicinae sont les plus abondantes non seulement en nombre d'espèces (16 espèces), mais aussi en occurrences (77). Le même constat a été noté par Taheri *et al.* (2014) dans le Parc National de Talassemtane au Maroc, Labbaci *et al.* (2019) dans le Parc National de Djurdjura en Kabylie et Henine-Maouche *et al.* (2020) dans le massif forestier de Guerrouche (Parc National de Taza) au nord de l'Algérie. La majorité des espèces (63 %) trouvées dans la forêt de Yakouren peuvent être qualifiées d'eu-forestières (*C. alii*, *C. lateralis*, *C. truncatus*, *T. atlantis*, *C. scutellaris algirica*, *A. crocea*, *T. recedens, T. algericus, T. spinosus*) et de méso-forestières (*A. canescens, A. mauritanica, A. sardoa ujhelyii, S. occipitalis, C. ruber, C. auberti levithorax, L. barbarus, P. maura*, *P. barbara*). Les formes méso-forestières et de lieux découverts s'installent dès que la forêt devient plus claire. Les espèces *A. sardoa ujhelyii*, *A. testaceopilosa canescens, S. occipitalis*, *C. truncatus*, *T. algiricus étant distinguées* comme caractéristiques du biotope. Cinquante ans plus tôt, Cagniant (1973) a pu recenser entre 13 et 24 espèces lors de prélèvements réalisés dans des emplacements comparables (chênaie mixte à 850 m d'altitude). Les relevés de cet auteur consistent en l'utilisation de la méthode des carrés qui se base sur les comptages de nids sur des surfaces standards de 10 x 10 m (au total 32 espèces)

L'utilisation de la méthode de collecte manuelle pour l'échantillonnage des fourmis a permis la capture de 81 % des espèces inventoriées dans la forêt de Yakouren.

La méthode des pots Barber a contribué avec 67 % alors que la chasse par les pièges appâts n'a pu apporter que 19 % de la richesse. La collecte manuelle fournit le plus grand nombre d'espèces lors d'un relevé (Barech *et al*., 2011, 2015, 2016, 2018) et augmente l'efficacité de l'échantillonnage, ainsi que le montre Groc (2006). Les espèces apportées par la chasse à vue (8 espèces) montrent que la combinaison de plusieurs méthodes offre plus de chance de rencontrer de nouvelles espèces. Selon le type d'habitat des fourmis, chaque méthode d'échantillonnage apporte des espèces particulières (Longino & Colwell, 1997).

Les différentes espèces recueillies par les pièges-appâts reflètent un aspect compétitif et préférentiel par rapport aux types d'aliments offerts. Les fourmis prises aux appâts sont généralement peu représentatives de la diversité réelle du site (Lebas *et al*., 2016), mais peuvent être utiles pour l'évaluation des groupes fonctionnels de fourmis (Andersen, 1997). Les appâts sont complémentaires des autres méthodes pour apprécier la biodiversité d'une station (Lebas *et al*., 2016).

Les pots Barber, les pièges appâts et la chasse à vue ont permis de capturer 73 % de la myrmécofaune présente dans la forêt. En comparant avec les résultats de Cagniant (1973), les espèces absentes dans notre étude, à savoir: *Proceratium algericum, Ponera coarctata, Stenamma africanum, Messor lobicornis, Crematogaster sordidula, Temnothorax annibalis, T. monjauzei, Myrmecina atlantis* avec en bordure *Bothriomyrmex atlantis,* et dans les parties plus clairsemées *Camponotus cruentatus et C. spissinodis,* justifient la croissance de la courbe d'accumulation des espèces observées et la divergence de celle-ci avec celles des estimateurs. La courbe d'accumulation n'atteint pas l'asymptote pour la totalité des relevés, ce qui témoigne d'un effort d'échantillonnage incomplet. Des relevés supplémentaires sont donc recommandés afin de rencontrer de nouvelles espèces.

Olson (1991) a constaté que le piégeage par les pots Barber est moins approprié pour l'échantillonnage des fourmis de litière en milieu forestier par rapport à la technique du Winkler qui apporte systématiquement plus de genres, d'espèces et d'ouvrières. Malheureusement, nous n'avons pas pu utiliser cette méthode qui faisait partie de notre protocole d'échantillonnage, car le site n'était pas assez sécurisé. Les sorties sur le terrain nécessitaient l'accompagnement de gardes forestiers dont la disponibilité n'était pas évidente. Ceci nous a amenés à minimiser le nombre de sorties et par conséquent le nombre de relevés. De plus, notre laboratoire ne disposait pas d'un piège Winkler approprié lors de l'élaboration de cette étude. D'un autre côté, les pots Barber sous-estiment la proportion des petites espèces. Ceci est observé dans la présente étude, où la plupart des espèces des genres *Temnothorax* et *Lasius* sont exclusivement collectées à la main. Bestelmeyer *et al*. (2000) notent que la technique du Winkler est commode pour les forêts. Par ailleurs Agosti & Alonso (2000) recommandent de combiner différentes méthodes de piégeage pour la capture des fourmis dans les milieux forestiers afin de dresser un inventaire le plus exhaustif possible.

La diversité observée dans le site d'étude est moyennement élevée; elle correspond à un peuplement composé d'un grand nombre d'espèces avec une faible représentativité. Des résultats semblables ont été notés par Henine-Maouche *et al.* (2020) dans les trois stations forestières du Parc National de Taza (Algérie) notamment celle du chêne-liège *Quercus suber*, du chêne algérien *Q. canariensis* et du chêne afarès *Q. afares*. Ces auteurs enregistrent des valeurs pour l'indice de diversité de Shannon variant de 2,19 à 2,86 bits. Ils signalent une distribution équilibrée pour les espèces trouvées dans les deux premières stations (E = 0.64).

Il n'existe pas une grande différence dans la distribution des occurrences pour les 27 espèces recensées dans la forêt de Yakouren, sauf pour *Pheidole pallidula* (20 occurrences), *Camponotus alii* (17 occurrences) et *Crematogaster scutellaris algirica* (16 occurrences). Les occurrences élevées des deux dernières espèces sont justifiables, car ce sont des espèces eu-forestières. Par contre, celle de *Pheidole pallidula* est le résultat d'une action conjuguée de l'anthropisation du milieu et de celle des feux répétés qu'a connue cette forêt ces dernières années. Henine-Maouche *et al.* (2020) mentionnent la présence de cette espèce uniquement dans la station de chêne-liège *Quercus suber*.

Les fourmis constituent de bons indicateurs écologiques; elles manifestent une sensibilité aux changements environnementaux (Cagniant, 1972; Ramage & Ravary, 2015). Nous avons dénombré dans la forêt de Yakouren huit espèces (30 %) indicatrices des actions anthropiques, à savoir *Tapinoma magnum*, *Lepisiota frauenfeldi atlantis*, *Cataglyphis viaticus*, *Crematogaster laestrygon normandi*, *Messor medioruber*, *Pheidole pallidula*, *Tetramorium biskrense* et *Tetramorium atlante*. Lorsque Cagniant (1973) a réalisé ses prélèvements entre 1963 et 1967, ces forêts étaient des zones militaires interdites aux publics. De ce fait, l'environnement s'est trouvé protégé durant plusieurs années contre les actions anthropiques, permettant ainsi une «remontée biologique» considérable. De même, il a été montré que la richesse spécifique des fourmis peut être fortement corrélée à celle de la flore, et donc par conséquent être un bon indicateur de l'état écologique d'un écosystème (Andersen *et al*., 1996).

En comparant les relevés, on constate une diminution relative des eu-forestières tandis que s'accroît l'abondance des anthropophiles. Ainsi *P. pallidula,* qui était «accidentelle» devient aujourd'hui «constante»; *T. biskrense* et *M. medioruber* ne figuraient pas dans les relevés. Les *Plagiolepis* constituaient 18 à 25 % des nids, *P. maura* plus xérophile que *P. barbara* ne nidifiait pas en pleine forêt. L'absence des espèces de sol profond dans les relevés actuels (*P. algericum, P. coarctata, S. africanum, M. atlantis*) traduit probablement une érosion plus

active des sols ou une méthode d'échantillonnage inappropriée, car ces espèces ne fourragent pas en surface. En contrepartie, *C alii* est abondante et même peut-être plus dominante. Elle est considérée comme une espèce très adaptative. Cette fourmi recherche le nectar des fleurs de cistes en particulier, ce qui est observé dans la forêt de Yakouren où le ciste *Cytisus triflorus* Lam. domine le sous-bois. L'occurrence élevée de *P. pallidula* révèle sa capacité de pénétration dans les forêts à la suite de son introduction avec le pâturage et les activités humaines; Bernard (1968) note que cette espèce pullule dans les forêts de chênes soumises à l'action anthropique. *C. auberti levithorax*, qui évite le couvert dense en forêt et trouve son optimum dans les suberaies assez claires, est «accidentel» (15 %) dans la forêt de Yakouren (il représentait moins de 3 % des nids dans les années 1960). Les *Temnothorax* se montrent sensibles aux perturbations de 1'environnement et disparaissent lorsque sévissent le déboisement, 1'érosion et le surpâturage (Cagniant & Espadaler, 1997a). Ils constituent donc des indicateurs écologiques et biocénotiques. Notre site d'échantillonnage abrite encore quatre espèces de *Temnothorax: T. atlantis, T. recedens, T. algiricus* et *T. spinosus*. Ce dernier est un bon indicateur de la santé d'une forêt de chênes ou de cèdres au Maghreb: il représente 16 à 28 % des nids dans les belles chênaies vertes à 1200 m d'altitude et jusqu'à 40 % des nids dans les cédraies à 1600 m autour d'Azrou au Maroc (Cagniant, 1973; Cagniant & Espadaler, 1997a; Taheri *et al*., 2014). A Yakouren, *T. spinosus* représentait jusqu'à 12 % des nids dans les relevés des années 1960 et semble à présent devenu plus rare (FO = 3 %). Les diverses espèces de *Lasius* qui représentaient 4 à 7 % des nids auparavant paraissent également en déclin. Il faut donc constater que la relative dégradation du milieu a entraîné une baisse notable de la biodiversité. Un indice supplémentaire de dégradation du site est la présence de *Lepisiota frauenfeldi atlantis*. Cette fourmi est nouvelle pour le milieu; c'est une thermophile qui envahit les lieux ensoleillés et que l'on trouve jusqu'au Sahara (Bernard, 1961).

La forêt de Yakouren a en effet connu ces dernières années des perturbations dues à plusieurs facteurs humains. Selon le Bureau national des études forestières (BEF), cette forêt est soumise à des pratiques néfastes (élevage extensif, arrachage des espèces végétales ligneuses et herbacées, défrichement, labour illicite et incendies). Ces pratiques se sont accentuées ces dernières années et ont abouti à un processus de dégradation en chaîne du domaine forestier (érosion, déséquilibre au niveau de l'environnement) (Boudedja & Abdelhakim, 2013). Le pourcentage de surface brûlée dans la forêt de Yakouren durant la période 1986-2005 atteint 86,42 % de la surface forestière totale (Meddour-Sahar, 2008). Le feu fait partie du fonctionnement des écosystèmes, toutefois, l'augmentation de leur fréquence a des impacts considérables sur la végétation, la faune, la microfaune, les sols, la déforestation, le climat et la perte de biodiversité (Triplet, 2020). D'après Dajoz (1998), les feux sont responsables de la fragmentation des forêts, ce qui isole les populations en empêchant leur dispersion et affecte l'abondance et la structure des populations d'insectes. Ce même auteur note que la construction de routes forestières, par exemple, représente souvent un obstacle infranchissable pour les insectes et crée de chaque côté une zone de lisière inhabitable pour certaines espèces en raison des modifications du microclimat. Les fourmis essaiment en volant parfois sur de longues distances, mais souvent des ailés viennent échouer au milieu des routes sans pouvoir les franchir.

La mise en place d'un marché traditionnel de poterie ces dernières années (depuis 1990), aux abords de la zone d'étude, semble avoir favorisé l'intrusion des fourmis anthropophiles comme *Tapinoma magnum* et *Pheidole pallidula*. Etant donné que la forêt est un conservatoire de biodiversité (Dajoz, 1998), la sur-fréquentation de celle-ci posera donc de délicats problèmes de gestion.

CONCLUSION

Malgré les perturbations environnementales (actions anthropiques, feux) que subissent les massifs de la Kabylie, les investigations myrmécologiques effectuées dans le cadre de notre étude dans la forêt de Yakouren témoignent d'une dégradation mineure du milieu par rapport aux travaux réalisés sur les fourmis depuis une cinquantaine d'années. Des recherches scientifiques sur ce groupe d'insectes bio-indicateurs au cœur de la forêt de Yakouren et d'autres massifs de la Kabylie devraient être poursuivies afin de mieux connaître les niveaux de biodiversité de ces *hotspots*. Une mise à jour taxonomique nous a permis de retenir de nouveaux statuts pour les taxons suivants:

- *Aphaenogaster sardoa ujhelyii* Szabó, 1910 **n. stat.**
- *Camponotus lateralis purius* Santschi, 1929 **n. stat.**
- *Crematogaster laestrygon normandi* Santschi, 1921 **n. stat.**
- *Crematogaster scutellaris algirica* (Lucas, 1849) **n. stat.**

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RÉFÉRENCES

Agosti D. & Alonso L. E. 2000. The ALL Protocol : A standard *protocol* for the collection of ground dwelling ants. *In* : Agosti D., Majer J., Alonso E., Schultz T. (eds), Ants : Standard Methods for Measuring and Monitoring Biodiversity. Biological Diversity Handbook Series. *Smithsonian Institution Press, Washington D.C.*, pp. 204-206.

Alonso L.E. 2000. Ants as indicators of diversity. *In* : Agosti D., Majer J., Alonso E., Schultz T. (eds), Ants : Standard Methods for Measuring and Monitoring Biodiversity. Biological Diversity Handbook Series. *Smithsonian Institution Press, Washington D.C.*, pp. 80-88.

Andersen A. 1997. Functional groups and patterns of organization in North American ant communities : a comparison with Australia. *Journal of Biogeography* 24(4) : 433-460.

Andersen A. N., Morrison S., Belbin L. 1996. The Role of Ants in Minesite Restoration in the Kakadu Region of Australia's Northern Territory, with Particular Reference to Their Use as Bio-indicators. Final Report to the Environmental Research Institute of the Supervising Scientist, Australia. 101 pp.

Andersen A.N., Fisher A., Hoffmann B.D., Read J.L., Richards R. 2004. Use of terrestrial invertebrates for biodiversity monitoring in Australian rangelands, with particular reference to ants. *Austral Ecology* 29 : 87-92.

Barech G., Khaldi M., Doumandji S., Espadaler X. 2011. One more country in the worldwide spread of the wooly ant : *Tetramorium lanuginosum* in Algeria (Hymenoptera : Formicidae). *Myrmecological News* 14 : 97-98.

Barech G., Rebbas K., Khaldi M., Doumandji S., Espadaler X. 2015. Redécouverte de la Fourmi d'Argentine *Linepithema humile* (Hymenoptera : Formicidae) en Algérie : Un fléau qui peut menacer la biodiversité. *Boletín de la Sociedad Entomológica Aragonesa (S.E.A.)* 56 : 269-272.

Barech G., Khaldi M., Ziane S., Zedam A., Doumandji S., Sharaf M., Espadaler X. 2016. A first checklist and diversity of ants (Hymenoptera : Formicidae) of the saline dry lake Chott El Hodna in Algeria, a Ramsar Conservation Wetland. *African Entomology* 24(1) : 143-152.

Barech G., Khaldi M., Espadaler X., Cagniant H. 2017. Le genre *Monomorium* (Hymenoptera, Formicidae) au Maghreb (Afrique du Nord) : Clé d'identification, avec la redescription de la fourmi *Monomorium major* Bernard, 1953 et nouvelles citations pour l'Algérie. *Boletín de la Sociedad Entomológica Aragonesa (S.E.A.)* 61 : 151-157.

Barech G., Khaldi M., Boujelal F-Z., Espadaler X. 2018. Diversité et structure de la myrmécofaune aux abords du barrage El Ksob en Algérie : nouvelle citation pour *Aphaenogaster rupestris* Forel, 1909 (Hymenoptera : Formicidae). *Boletín de la Sociedad Entomológica Aragonesa (S.E.A.)* 62 : 253-258.

Bernard F. 1961. Biotopes habituels des Fourmis sahariennes de plaine d'après l'abondance de leurs nids en 60 stations très diverses. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord* 52 : 21-40.

Bernard F. 1968. Faune de l'Europe et du Bassin Méditerranéen. 3. Les Fourmis (Hymenoptera Formicidae) d'Europe Occidentale et Septentrionale. *Masson, Paris, France*, 411 pp.

Bestelmeyer B.T., Agosti D., Alonso L.E., Brandão C.R.F., Brown W.L., Delabie J.H.C., Silvestre R. 2000. Field Techniques for the Study of Ground-Dwelling Ants : An Overview, Description and Evaluation. *In* : Agosti D., Majer J., Alonso E., Schultz T. (Eds), Ants : Standard Methods for Measuring and Monitoring Biodiversity. Biological Diversity Handbook Series. *Smithsonian Institution Press. Washington D.C.*, pp. 122-144.

Bigot L., Bodot P. 1973. Contribution à l'étude biocénotique de la garrigue à *Quercus coccifera*. *Vie et milieu*, fasc. 2, sér. C 23 : 229-249.

Bolton B. 2020. An online catalog of the ants of the world. Available from https ://antcat.org. (accessed [10/08/2020])

Boudedja K., Abdelhakim T. 2013. Emergence et résurgence de représentations territoriales face à des mutations socio-économiques dans un territoire rural forestier en Algérie. *Autrepart* (66) : 21-42.

Cagniant H. 1968. Liste préliminaire de fourmis forestières d'Algérie, résultats obtenus de 1963 à 1966. *Bulletin de la société d'histoire naturelle de Toulouse* 104(1-2) : 138-146.

Cagniant H. 1970. Deuxième liste de fourmis d'Algérie, récoltées principalement en forêt (1re partie). *Bulletin de la société d'histoire naturelle de Toulouse* 105 : 405-430.

Cagniant H. 1972. Note sur les peuplements de Fourmis en forêt d'Algérie. *Bulletin de la société d'histoire naturelle de Toulouse* 108 : 386-390.

Cagniant H. 1973. Les peuplements de fourmis des forêts algériennes. Ecologie, biocénotique, essai biologique. *Thèse Doctorat, Université Paul Sabatier, Toulouse*, France, 464 pp.

Cagniant H. 1996a. Les *Aphaenogaster* du Maroc (Hymenoptera : Formicidae) : clé et catalogue des espèces. *Annales de la Société entomologique de France (N.S.)* 32 : 67-85.

Cagniant H. 1996b. Les *Camponotus* du Maroc (Hymenoptera : Formicidae) : clé et catalogue des espèces. *Annales de la Société entomologique de France* (N.S.) 32 : 87-100.

Cagniant H. 2005. Les *Crematogaster* du Maroc. Clé de détermination et commentaires. *Orsis* 20 : 7-12.

Cagniant H., Espadaler X. 1997a. Les *Leptothorax*, *Epimyrma* et *Chalepoxenus* du Maroc (Hymenoptera : Formicidae). Clé et catalogue des espèces. *Annales de la Société entomologique de France* (N.S.) 33 : 259-284.

Cagniant H., Espadaler X. 1997b. Le genre *Messor* au Maroc (Hymenoptera : Formicidae). *Annales de la Société entomologique de France* (N.S.) 33 : 419-434.

Colwell R.K. 2013. EstimateS : Statistical estimation of species richness and shared species from samples. Version 9.1.0 User's Guide and application. Available at : http ://viceroy.colorado.edu/estimates/.

Dajoz R. 1998. Les insectes et la forêt. *Ed. Technique et Documentation*, Paris, 594 pp.

Faurie C., Ferra C., Medori P., Deveaux J., Hemptinne J.L. 2003. Ecologie : Approche scientifique et pratique. 5ème édition, *Tec & Doc, Paris,* 408 pp.

Gotelli N.J., Ellison A.M., Dunn R.R., Sanders N.J. 2011. Counting ants (Hymenoptera : Formicidae) : biodiversity sampling and statistical analysis for myrmecologists. *Myrmecological News* 15 : 13-19.

Groc S. 2006. Diversité de la myrmécofaune des Causses aveyronnais – Comparaison de différentes méthodes d'échantillonnage. *Mémoire de DESUPS. Université Paul Sabatier*, 39 pp.

Haddar L., Doumandji S., Pujade-Villar J. 2016. Les Cynipini et les Synergini dans les massifs de l'Akfadou et Beni-Ghobri (Algérie), présences de quelques espèces sur des hôtes atypiques (Hym., Cynipidae). *Boletín de la Asociación Española de Entomología* 40(3-4) : 479-493.

Hammer Ø., Harper D.A.T., Ryan P.D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica* 4(1) : 1-9, available at : http://palaeo-electronica.org/2001_1/past/issue1_01.htm.

Henine-Maouche A., Tahraoui A., Moulai R. 2020. Ants' diversity (Hymenoptera-Formicidae) in the Algeria's humid forests, case of the Guerrouche forest massif (Taza National Park). *Sociobiology* 67(2) : 153-162.

Hölldobler B., Wilson E.O. 1990. The ants. *Harvard University Press, Cambridge, MA,* 732 pp.

Kasseney B.D., N'tie T.B., Nuto Y., Wouter D., Yeo K., Glitho I.A. 2019. Diversity of Ants and Termites of the Botanical Garden of the University of Lomé, Togo. *Insects* 10(7) : 218.

Labbaci A., Marniche F., Daoudi-Hacini S., Boulay R., Milla A. 2019. Species diversity of myrmecofauna (Hymenoptera, Formicidae) on the southern slope of Djurdjura National Park (Northern Algeria). *Arxius de Miscellània Zoològica* 17 : 219-229.

Lebas C., Galkowski C., Blatrix R., Wegnez P. 2016. Fourmis d'Europe occidentale. *Delachaux & Niestlé*, 415 pp.

Longino J.T. 2000. What to do with the data. *In*: Agosti D., Majer J., Alonso E., Schultz T. (eds), Ants: Standard Methods for Measuring and Monitoring Biodiversity. Biological Diversity Handbook Series. *Smithsonian Institution Press, Washington D.C.*, pp. 186-203.

Longino J.T., Colwell R.K. 1997. Biodiversity assessment using structured inventory : capturing the ant fauna of a tropical rain forest. *Ecological Applications* 7 : 1263-1277.

Longino J.T., Coddington J., Colwell R. K. 2002. The ant fauna of a tropical rain forest : estimating species richness three different ways. *Ecology* 83(3) : 689-702.

Majer J.D. 1983. Ants : Bio-lndicators of minesite rehabilitation, Land-Use, and Land Conservation. *Environmental Management* 7(4) : 375-383.

Martelli M.G., Ward M.M., Fraser A.M. 2004. Ant diversity sampling on the southern cumberland plateau : a comparison of litter sifting and pitfall trapping. *Southeastern Naturalist* 3(1) : 113-126.

Médail F., Quézel P. 1997. Hot-Spots Analysis for Conservation of Plant Biodiversity in the Mediterranean Basin. *Annals of the Missouri Botanical Garden* 84(1) : 112-127.

Meddour-Sahar O. 2008. Contribution à l'étude des feux de forêts en Algérie : Approche statistique exploratoire et socio-économique dans la wialya de Tizi Ouzou. *Thèse Magister, INA, El Harrach*, Alger, 275 pp.

Messaoudène M., Laribi M., Derridj A. 2007. Etude de la diversité floristique de la forêt de l'Akfadou (Algérie). *Bois et forêts des tropiques* 291 : 75-81.

Olson D. M. 1991. A comparison of the efficacy of litter sifting and pitfall traps for sampling leaf litter ants (Hymenoptera, Formicidae) in a tropical wet forest, Costa Rica. *Biotropica* 23(2) : 166-172.

Ramage T., Ravary F. 2015. Les bioindicateurs myrmécologiques : synthèse bibliographique. *Rapport de l'Observatoire de l'Environnement en Nouvelle-Calédonie (OEIL)*, 38 pp.

Santschi F. 1929. Fourmis du Maroc, d'Algérie et de Tunisie. *Bulletin et Annales de la Société Entomologique de Belgique* 69 : 138-165

Santschi F. 1933. Etude sur le sous-genre *Aphaenogaster* Mayr. *Revue suisse de Zoologie* 40 : 389-408.

Schomaker M. E., Zarnoch S. J., Bechtold W. A., Latelle D. J., Burkman W. G., Cox S. M. 2007. Crown-condition classification : a guide to data collection and analysis. Gen. Tech. Rep. SRS-102. Asheville, NC : U.S. *Department of Agriculture, Forest Service, Southern Research Station.*

Seifert B. 2019. A taxonomic revision of the members of the *Camponotus lateralis* species group (Hymenoptera : Formicidae) from Europe, Asia Minor and Caucasia. *Soil Organisms* 91 : 7-32.

Shorthouse D. P. 2010. SimpleMappr, an online tool to produce publication-quality point maps. [Retrieved from https://www.simplemappr.net. Accessed November 16, 2020].

Statsoft, INC. 2012. STATISTICA (data analysis software system), version 8. Available at : www.statsoft.com.

Szabó J. 1910. Formicides nouveaux ou peu connus des collections du Musée National Hongrois. Dummy reference. *Annales Historico-Naturales Musei Nationalis Hungarici* (8) : 364-369.

Taheri A., Reyes-Lopez J.L., Bennas N. 2014. Contribution à l'étude de la faune myrmécologique du Parc National de Talassemtane (Nord du Maroc) : biodiversité, biogéographie et espèces indicatrices. *Boletín de la Sociedad Entomológica Aragon*esa (54) : 225-236.

Triplet P. 2020. Dictionnaire Encyclopédique de la Diversité Biologique et de la Conservation de la Nature. 6th edition. ISBN : 978-2-9552171-5-3. Online at : https://medwet.org/fr/2020/02/dictionnaire-diversite-biologique-2020/

Véla E., Benhouhou S. 2007. Evaluation d'un nouveau point chaud de biodiversité végétale dans le bassin méditerranéen (Afrique du Nord). *Comptes Rendus Biologie* 330 : 589-605.

Wang C., Strazanac J., Butler L. 2001. A Comparison of pitfall traps with bait traps for studying leaf litter ant communities. *Journal of Economic Entomology* 94(3) : 761-765.

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A taxonomic review of the genus *Diptychophora* Zeller (Lepidoptera, Pyralidae *sensu lato*, Crambinae) in Brazil, with descriptions of three new species

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Abstract: The Brazilian fauna of *Diptychophora* Zeller, 1866 (Lepidoptera, Pyralidae *sensu lato*, Crambinae) is reviewed. Consisting of three species based on the literature (*D. diasticta* Gaskin, 1986, *D. kuhlweinii* Zeller, 1866 and *D. subazanalis* Błeszyński, 1967), this fauna is augmented with three new species (*Diptychophora galvani* sp. n. from Mato Grosso and Minas Gerais, *D. planaltina* sp. n. from the Federal District, and *D. ardalia* sp. n. from Bahia), that are described and illustrated. The female of *D. diasticta* is also described and illustrated for the first time. A partial CO1 barcode sequence is provided for *D. diasticta*.

Keywords: Pyraloidea - Crambidae - Diptychophorini - New World - checklist.

INTRODUCTION

Among Crambinae, the Diptychophorini include the smallest, and also many of the most colourful species. As shown by Léger *et al.* (2019), the tribe is at the base of the Crambinae phylogenetic tree. In the New World there are currently six recognized genera of Diptychophorini that include 25 species (see Nuss *et al.*, 2020). The New World fauna of Diptychophorini, except *Microcausta* Hampson, 1895 was revised by Gaskin (1986a, b; 1989) with additions by Landry (1990) and Solis (2009). The genus *Diptychophora* Zeller, 1866 includes nine New World species occurring from the United States of America in Arizona south to the southern State of Santa Catarina in Brazil. In Brazil there are three species of *Diptychophora* recorded. We list and illustrate these with photos of the habitus and describe three additional species. The three new species were found in the Cerrado, a major ecoregion of Brazil between the Amazonian rainforest and the Atlantic Forest. Seasonally dry, it consists of a variety of more or less wooded savanna types, as well as wetlands and gallery forests, on poor acidic soils.

MATERIAL AND METHODS

The specimens treated here were mostly collected by VB in glass vials with a mercury-vapour lamp in front of a white sheet. They were kept alive until the next day, when they were killed in jars with ethylic ether and pinned in plastic boxes with plastazote glued to the bottom. Static electricity, generated by rubbing the plastazote with curved forceps, was used to spread the wings. Ethylic ether works well for this manoeuver as the wing muscles are not too relaxed and remain open on the plastazote surface.

Specimens were dissected in 30% ethanol following maceration in KOH at 60 °C for one hour, or 14 hours or so at room temperature. Dissected parts were stored temporarily in lactic acid stained with Orange G to allow for the action of KOH to stop, for staining the sclerotized parts, and to allow their description in three dimensions, although in this study some specimens had been dissected and mounted on slides 12 years before description. Mounting included a short staining period in Chlorazol black. Euparal was used as a mounting medium.

Photos were taken with a Leica M205 and a Leica DFC425 camera and its associated imaging software. Some of the photographed specimens (Figs 1, 3-5, 8) had the wings bent down and thus, wingspan calculations based on the scales provided on the photos will give smaller values than those provided here in the descriptions and diagnoses. The photos were stacked using Zerene Stacker of Zerene Systems LLC and enhanced using Gimp and Adobe Photoshop.

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To help describe and compare the shape of the male valva of the three new species, two measurements were taken on the right valva from photos of mounted genitalia (Figs 11, 13-16): the length of the dorsal section measured from the lowest point of the basal concavity of the dorsal edge until the apex, and the width measured from that same point of the dorsal edge at base to the widest point on the ventral edge. The ratio of these two measurements is here called the length/width ratio of the valva.

DNA extractions were made on 12 specimens of *Diptychophora* following three different protocols, as follows. 1– DNA was extracted from two legs each of four specimens at the MHN, Geneva using the commercial kit EZNA Tissue DNA (Omega Bio-Tek) and following the manufacturer's instructions. Amplification of the COI barcode region was attempted using PCR protocols detailed in Landry & Andriollo (2020). 2 & 3 – DNA was extracted from one leg each of 12 specimens and from the abdomen of four of these same specimens by Théo Léger at the MfN using the Macherey-Nagel DNA extraction kit. The COI barcode region was amplified using the LCO/Nancy primer combination. Because the full CO1 barcode region amplifications consistently failed, two fragments, COI-1a (LCO/K699) and COI-1b (COIf220/Nancy), were amplified separately. The molecular procedure follows that of Léger *et al*. (2021). Sequencing was done in both directions by Macrogen (The Netherlands).

The following abbreviations are used: 'BL' for Bernard Landry, 'col.' for collector, 'm' for meter(s), 'NHMUK' for Natural History Museum, London, U.K., 'CUIC' for Cornell University Insect Collection, Ithaca, New York, U.S.A., 'MfN' for 'Museum für Naturkunde', Berlin, Germany, 'MHNG' for 'Muséum d'histoire naturelle', Geneva, Switzerland, 'USNM' for National Museum of Natural History, Washington, D.C., U.S.A., 'VB' for Vitor Becker, and VBC for Vitor O. Becker Collection, Camacan, Brazil.

SEQUENCING RESULTS

The DNA extractions from specimen legs at the MHNG and MfN failed to provide any product usable for sequencing. The DNA extractions from abdomens at the MfN were mostly unsuccessful except for one specimen of *D. diasticta* for which the terminal 333 base-pairs could be retrieved and is presented below.

TAXONOMIC SECTION

Diptychophora Zeller, 1866

The genus *Diptychophora* (type species *Diptychophora kuhlweinii* Zeller, 1866) is presently known to include 15 species from the Old and New Worlds (Nuss *et al.*, 2020), although the Old World species placed in *Diptychophora* probably belong in fact to *Glaucocharis* Meyrick, 1938. The New World fauna of *Diptychophora* includes nine described species (Nuss *et al*., 2020) that occur from the southwestern United States of America (Arizona) south to the state of Santa Catarina in the south of Brazil. The Neotropical fauna was revised by Gaskin (1986a). Landry (1990) added two new species and Solis (2009) transferred an additional species from Cybalomiinae to *Diptychophora*. Although synapomorphies have not been presented for the genus yet, *D. powelli* Landry (1990) as well as the species transferred by Solis (2009), i.e. *D. lojanalis* (Dognin, 1905), do not exhibit the typical valva shape of *Diptychophora* and hence may require new genera or transfers to other existing genera. No larval host is presently known for the species of *Diptychophora*.

***Diptychophora galvani* sp. n.**

Figs 8, 13, 17

Material examined

Holotype: female; VBC, without catalogue number; Brazil, Mato Grosso, Chapada dos Guimarães, 800 m; 7-8.04.1996; V.O. Becker collector; Collection Becker 106575.

Paratypes (2 males, 1 female): 1 male; MHNG-ENTO-84604 (dissected); same data as holotype; DNA voucher Lepidoptera B. Landry n°043. – 1 female; VBC, without catalogue number; Brazil, Minas Gerais, Unaí, 700 m; 03.11.1983; V.O. Becker, collector; Collection Becker 49809; genitalia slide BL 1880. – 1 male; VBC, without catalogue number; Brazil, Minas Gerais, Unaí, 700 m; 07.11.1982; V.O. Becker, collector; Collection Becker 49079.

Diagnosis: No other species of *Diptychophora* have a forewing pattern in any way similar to that of this species in the large median grey section bordered by dark brown lines and preceded and followed by orange sections. In male genitalia the elongate uncus fused with the tegumen represents a distinctive feature and in female genitalia, the presence of two signa, one crescentic and the other crease-shaped, is unique among the New World members of *Diptychophora*.

Etymology: This new taxon is named in honour of Dr Ricardo Magnus Osório Galvão, professor of the Institute of Physics of the University of São Paulo, for his courage in the face of professional adversity. The orange colour of the moth's forewings are reminiscent of the devastating fires that had become more prevalent in the Amazon in 2019, compared to 2018, based on Dr Galvão and his team's scientific data that cost Dr Galvão his position of Director of the Brazilian National Institute for Space Research in August 2019.

Description: (Fig. 8). Head with frons slightly rounded, not projecting, with vestiture short scaled, white to pale yellow on ventral half, yellowish orange above and between antennae; posterior eye margin scales

pale yellow to yellowish orange; vertex and occiput with undercover of short and thin white scales covered by posterolateral tuft of thin yellowish orange scales projecting medioanteriorly to medioposteriorly. Antenna dark brown dorsally and white ventrally on scape, pedicel and first 1-2 flagellomeres, light yellowish brown on subsequent flagellomeres. Maxillary palpus white at base, light yellowish orange toward apex. Labial palpus not reaching beyond yellowish orange apex of maxillary palpus, with vestiture mostly white to light yellow, with some pale greyish brown laterally at base. Haustellum white scaled. Thorax with patagia orange with pale dark brown at tip laterally; tegula orange with dark brown base; between tegulae orange with broad dark brown bars from base to middle; apex with orange medially and white laterally. Male forewing length: 4.5 mm, wingspan: 10.0 mm. Female forewing length: 5.0-5.5 (holotype: 5.0 mm), wingspan 11.0-12.0 mm (holotype: 11.0 mm). Female frenulum with 2 or 3 acanthae, not clearly visible on available specimens. Male with white hindwing with terminal margin at apex light brown and with white fringes except for grey brown tips of apical scales; female wings with colour and pattern as illustrated (Fig. 8). Prothoracic leg coxa and trochanter white and light yellowish brown; femur yellowish brown, darker blackish brown at tip, white medially at base; tibia orange at base, dark brown on second half, white at tip; first tarsomere light yellowish orange at base, subsequently dark brown and white at tip; second tarsomere white; third and fourth tarsomeres dark brown; fifth white. Mesothoracic leg coxa and trochanter white with some light yellow; femur light yellowish orange with greyish brown at apex; tibia and first tarsomere light yellowish orange; second and third tarsomeres white with dark brown base; fourth white; fifth dark brown with white tip. Metathoracic leg coxa, trochanter, femur, tibia, and first tarsomere pale dirty yellowish white, second to fifth tarsomeres as on mesothoracic leg. Male abdomen pale yellowish white all around. Female abdomen dorsally mostly greyish brown, with pale dirty yellowish white on first tergite apically and yellowish grey at apex; ventrally yellowish white. Female abdominal segment VII about twice as long as preceding segment, narrower, more thickly sclerotized and thickly scaled along apical margin.

Male genitalia (n=1) (Fig. 13). Uncus elongate, triangular in side view, without clearly visible line of demarcation from tegumen; distal section of medium girth, apically triangular and slightly upturned. Subscaphium distinctly sclerotized, forming thin band narrowing to apical point. Gnathos thin, with distal arm at right angle from shorter lateral arms, slightly curving upward at about 1/3 and apically, reaching tip of subscaphium. Tegumen with posterior lateral arms straight and narrow, anterior plates distinctly separated from posterior arms from mid-length, subtriangular, with broadly rounded posterior margin. Juxta shield like, with convex lateral margins, with apical margin V-shaped. Valva short, slightly longer than broad (length/width ratio: 1.17), with dorsal section about 3X as produced as ventral section and more abundantly setose along dorsal margin on apical third. Vinculum very narrow, with short, rounded median projection. Phallus slightly shorter than valva, straight, of medium girth, mostly membranous, ventrally with thin sclerotized band enlarging subapically to cover ventral wall and lateral walls partly; vesica adorned with numerous spinules on apical third in invaginated state.

Female genitalia (n=1) (Fig. 17). Papillae anales small, subtriangular, ventrally longer, narrowing to about half of ventral length dorsally, moderately setose and covered with setulae. Posterior apophysis connecting to sclerotized plate of base of papilla analis at its dorsal edge, short, about as long as width of papilla analis, straight, reaching about middle of segment VIII. Tergite VIII of medium length; anterior apophysis about as long as posterior apophysis but slightly sturdier and bent at about 1/3. Ostium bursae a wide membranous funnel adorned with several transverse rows of fine and short sclerotized striae. Ductus bursae of medium girth, bent subbasally, spinulate, and lightly sclerotized in bend ventrally, scobinated partly on median third and all around on distal third. Ductus seminalis connecting on right side of ductus bursae at about 1/3 from its base. Corpus bursae large, almost as long as ductus bursae, subcircular, with right margin nearly straight, scobinated all around, but more thickly so at base and around signa; with thin, boomerang-shaped signum at about 1/3 from base and smaller rounded signum forming crease on opposite side and slightly closer to base.

Biology: Unknown. The specimens were collected in the Cerrado Biome, at the edge of gallery forest.

Distribution: Presently known from Brazil only, specimens were collected in the states of Mato Grosso and Minas Gerais.

Remarks: Two more specimens in the NHMUK were unavailable during the time of the description and hence not included in the type series.

Diptychophora planaltina sp. n.

Figs 6, 7, 15, 19

Material examined

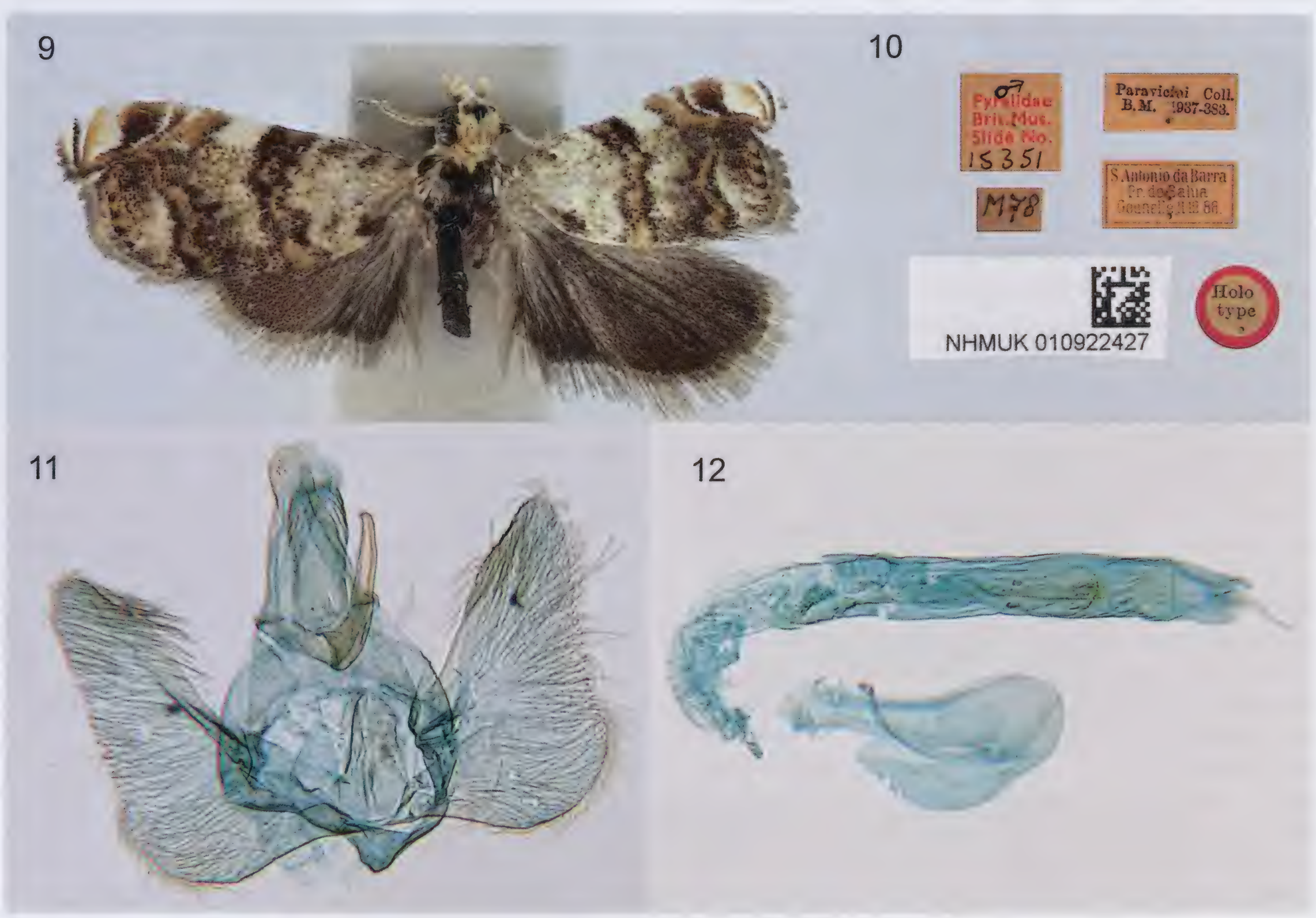
Holotype: male; VBC, without catalogue number; Brazil, Federal District, Planaltina, 1100 m; 15.02.1990; V.O. Becker collector; Collection Becker 96721.

Paratypes (8 males, 2 females): – 1 male; VBC, without catalogue number; same data as holotype. – 1 female; MHNG-ENTO-85386 (dissected); same data as holotype; DNA voucher Lepidoptera B. Landry n°048. – 2 males; VBC, without catalogue numbers; Brazil, Federal District, Planaltina, 1100 m; 16.10.1990; V.O. Becker

Figs 1-8. Habiti of *Diptychophora* species. (1) *D. subazanalis* female, Brazil, Rondonia (VBC). (2) *D. kuhlweinii* male, Brazil, Bahia (MHNG). (3) *D. diasticta*, male, Brazil, Minas Gerais (VBC). (4) *D. diasticta*, female, Brazil, Minas Gerais (VBC). (5) *D. ardalia*, holotype (VBC). (6) *D. planaltina*, holotype (VBC). (7) *D. planaltina*, paratype female, Brazil, Federal District (VBC). (8) *D. galvani*, holotype (VBC).

collector; Collection Becker 96857. – 1 male; MHNG-ENTO-85387 (dissected); Brazil, Federal District, Planaltina, 15°35'S, 47°42'W, 1000 m; 10.10.1983; V.O. Becker collector; Collection Becker 41534. – 2 males; VBC, without catalogue numbers; Brazil, Federal District, Planaltina, 15°35'S, 47°42'W, 1000 m; 05.11.1988; V.O. Becker collector; Collection Becker 58960. – 1 male; VBC, without catalogue number; Brazil, Federal District, Planaltina, 15°35'S, 47°42'W, 1000 m; 15.02.1982; V.O. Becker collector; Collection Becker 39741. – 1 male; VBC, without catalogue number; Brazil, Federal District, Planaltina, 15°35'S, 47°42'W, 1000 m; 22.02.1985; V.O. Becker collector; Collection Becker 57204. – 1 female; VBC, without catalogue number; Brazil, Federal District, Planaltina, 15°35'S, 47°42'W, 1000 m; 15.04.1985; V.O. Becker collector; Collection Becker 57399.

Diagnosis: The male of this species is distinctive in the wide orange and dark brown basal, submedian, and postmedian jagged fasciae on a satiny white background. Other species of Diptychophorini have orange brown and/or dark brown fasciae on a satiny white background [*Diptychophora kuhlweinii* Zeller (Fig. 2), *D. subazanalis* Błeszyński (Fig. 1), *Steneromene azanalis* (Walker)], but their fasciae are thin and usually straight, especially the submedian fascia. This species is more similar in forewing pattern and colour to some species of the Crambinae genus *Microcrambus* Błeszyński formerly placed in *Tortriculladia* Błeszyński (see Léger *et al.,* 2019), except for the obvious notch on the forewing terminal margin that all New World Diptychophorini possess, except *Microcausta* Hampson. The male genitalia (Fig. 15) are similar to those of *D. ardalia* (Fig. 16), but differ conspicuously in the more elongate dorsal section of the valva, which has a ratio of length/width of 1.2 whereas that ratio only reaches 1.0 in the more squarish valva of *D. ardalia*. That ratio is 1.2 also in *D. diasticta* (Fig. 14), but this species differs from *D. planaltina* in its longer uncus and gnathos that do not reach the tip of the valva, and the wider uncus in side view, with a ratio of length over width of 3.7 in *D. diasticta* vs 4.24 in *D. planaltina*. In *D. planaltina* the 7.5 ratio of the length of the sclerotized section of the phallus shaft over its width is the longest of the three species as it is only 4.6 for *D. diasticta* and 6.2 for *D. ardalia*. In female genitalia this species (Fig. 19) is most similar to *D. diasticta* (Fig. 18), but its papillae anales are larger,



Figs 9-12. Holotype male of *Diptychophora diasticta* Gaskin in NHMUK. (9) Habitus. (10) Habitus labels. (11) Genitalia without phallus. (12) Phallus. Photos by David Lees, © Courtesy of the Trustees of the Natural History Museum, London, U.K.

its anterior apophyses are straight instead of sinuous, and the distal half of the corpus bursae is narrower that the proximal half whereas only the distal quarter is narrower in *D. diasticta*.

Etymology: The name refers to the type locality and is treated as a noun in apposition.

Description: Male (n=8) (Fig. 6). Head with frons rounded, slightly bulging; vestiture on frons short scaled with brown spot in middle, on vertex and occiput with thinner and longer scales mostly white, with light yellowish to greyish brown laterally on posterior fan of scales projecting medioanteriorly between antennae to medioposteriorly. Antennal scape and pedicel dark brown dorsally and white ventrally; flagellomeres with dark brown to greyish brown and lighter greyish brown scales. Maxillary palpus dark brown at base, white on longer projecting scales of distal half. Labial palpus porrect, reaching slightly beyond maxillary palpus, with scales appressed, white at base and apically, greyish brown laterally at base, light yellowish to light greyish brown elsewhere. Haustellum light yellowish brown. Thorax with patagium laterally white, medially yellowish brown at base and dark brown at apex of scales; tegula white with patch of blackish brown at base and light yellowish brown to brown at apex; between tegulae blackish brown at base, followed by white, medially blackish brown followed by white scales tipped yellowish brown, apically white with brown laterally. Male forewing length: 5.5-6.5 mm (holotype 6.0 mm); wingspan: 11.5-13.0 mm (holotype: 12.0 mm). Female forewing length: 5.5-6.5 mm; wingspan 12.0-12.5 mm. Female frenulum with 2 or 3 acanthae. Male wings with pattern and colours as illustrated (Fig. 6), with purplish shine in forewing fringe at level of terminal black dots. Female generally with darker wings than male, as shown (Fig. 7), with darker frons, labial palpus, and legs to a lesser extent. Prothoracic leg coxa laterally white, medially greyish brown with white apex; trochanter white; femur dark greyish brown with white ventral edge; tibia greyish brown at base, dirty white near middle, mostly blackish brown on distal half, with white apically; first tarsomere white at base and apex, blackish brown in middle; second tarsomere white; third and fourth tarsomeres blackish brown; distitarsus white. Meso- and metathoracic leg coxa and trochanter white to light yellowish brown; femur white with greyish brown apex; tibia white with greyish brown dorsally and on spurs; first tarsomere greyish brown with white at base and apex; tarsomeres II-V blackish brown on basal half or more, white at apex. Abdomen dorsally light yellowish brown on first three tergites and at apex, light greyish brown in between; ventrally uniformly yellowish brown. Female abdominal segment VII about twice as long as preceding segment, narrower, slightly more thickly sclerotized and thickly scaled along apical margin.

Male genitalia (n=2) (Fig. 15). Uncus + subscaphium + gnathos short, not reaching apex of valva. Uncus elongate, narrow in side view, with ratio of length over width of 4.24, unevenly narrowing towards apex, with distal 1/5 narrowing more conspicuously until flat apex; with clear demarcation from tegumen at base; apically upturned slightly. Subscaphium distinctly sclerotized, with wrinkles on distal half and with distal third slightly bent upward. Gnathos with base of distal arm ventrally forming distinctly obtuse angle with proximal arms and subsequent conspicuously pronounced curve; apically curved upward and not reaching tip of subscaphium. Tegumen medium-sized, with lateral arms about as wide as dorsal connection, separated in two. Juxta about twice as long as wide, with more thickly sclerotized base, mediolongitudinal strut, and slightly concave apical edge medially. Valva medium-sized, slightly longer than broad (length/width ratio: 1.2); longer dorsal section more abundantly setose especially along dorsal margin on apical third and with short, flat triangular projection along edge slightly beyond middle; ventral section barely produced, with broadly rounded ventroapical margin. Vinculum very narrow, with tiny rounded median projection. Phallus a long narrow tube, twice as long as valva, with sclerotized shaft about 7.5 times longer than wide, slightly bent, with thickly sclerotized ventral strut only slightly enlarging apically; vesica with at least two elongate sections covered with spinules.

Female genitalia (n=1) (Fig. 19). Papillae anales medium sized, abundantly setose and spinulate, subtriangular in lateral aspect, with setose surface about half as long ventrally as dorsally, with apical margin slightly concave medially. Posterior apophysis straight, long, about 2X as long as width of papilla analis, reaching apical margin of segment VII in extension. Tergite VIII of medium length, about as long as width of papilla analis; anterior apophysis of medium length, about 40% shorter than posterior apophysis, with slight bend subbasally. Ostium bursae a spinulate, membranous conical funnel nearly as wide as segment and as long as wide, with lamella postvaginalis also lightly spinulate. Ductus bursae with short basal section devoid of sclerotization or scobination, followed by sharp bend and longer scobinated section reaching median connection of ductus seminalis on right side, with distal half about twice as wide, slightly enlarging and scobinated. Corpus bursae narrow, elongate, with longer and narrower distal half, reaching abdominal segment III, lightly scobinated at base and even more lightly toward distal end, with pair of small circular signa laterally at base, with right signum closer to base than left signum.

Biology: Unknown. The type locality is in the Cerrado Biome, the savanna biome of Central Brazil.

Distribution: Presently known only from Planaltina, a locality situated within the Federal District of Brazil.

Remarks: The holotype's left prothoracic leg is

broken beyond the trochanter; otherwise it is in perfect condition (Fig. 6).

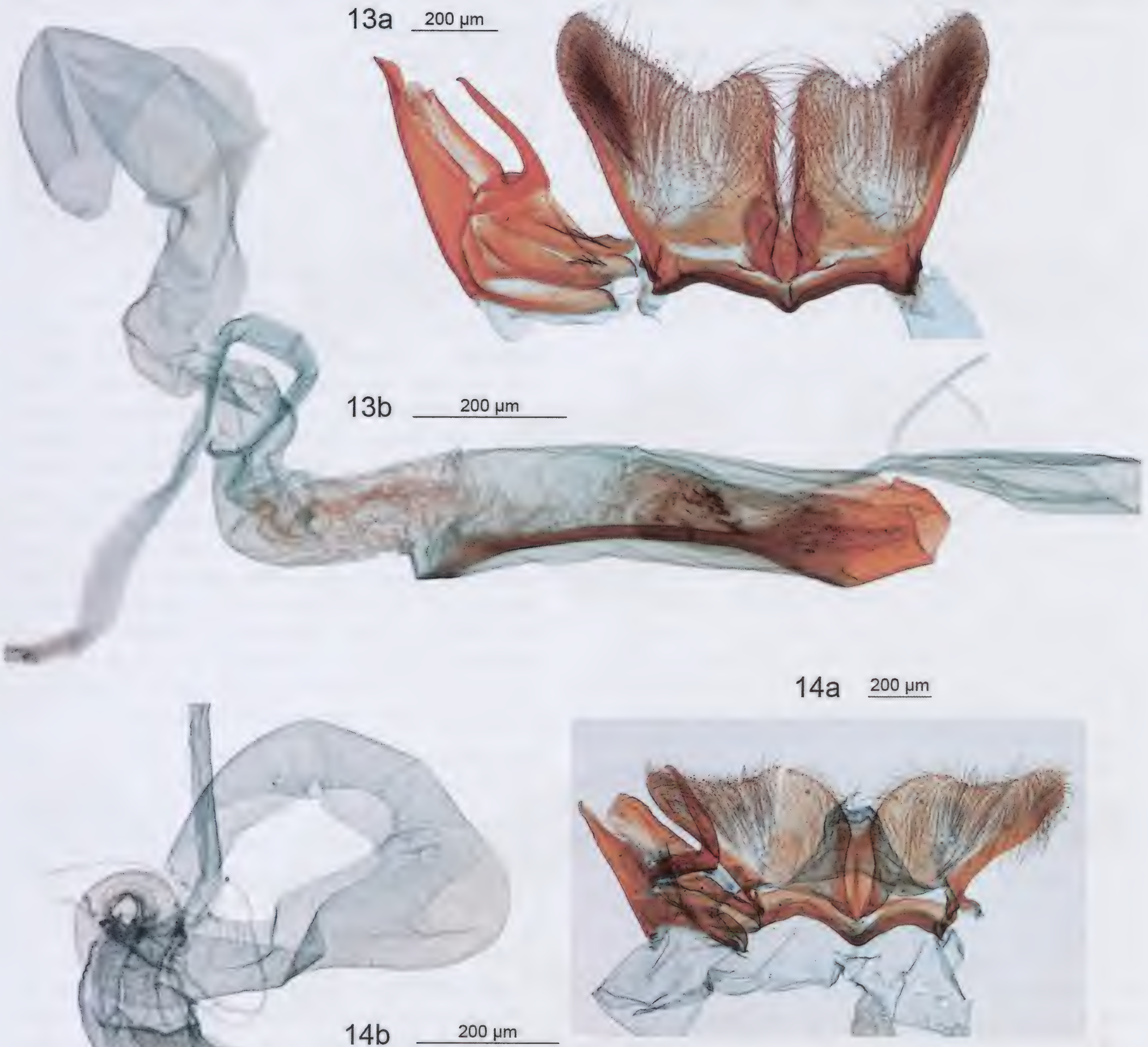
Diptychophora diasticta Gaskin, 1986

Figs 3, 4, 9-12, 14, 18

Material examined

Holotype: male; NHMUK 010922427; Brazil, Bahia, Santo Antônio de Barra; 11.12.1888; P.-E. Gounelle; NHMUK; slide n° Pyralidae Brit. Mus. 15351 (NHMUK 010316677_15351).

Additional material (2 males, 3 females): 1 female; VBC, without catalogue number; Brazil, Minas Gerais, Caraça, 1300 m; 04.03.1993; V. O. Becker, collector; Collection Becker 85332; genitalia slide BL 1876; DNA voucher Lepidoptera B. Landry n° 049. – 1 male; VBC, without catalogue number; Brazil, Minas Gerais, Caraça, 1300 m; 01-02.04.1992; V. O. Becker, collector;



Figs 13-14. Male genitalia of *Diptychophora* species, (a) without phallus, (b) phallus. (13) *D. galvani*. (14) *D. diasticta*.

Collection Becker 85090; genitalia slide BL 1880. – 1 female; VBC, without catalogue number; Brazil, Minas Gerais, Caraça, 1300 m; 14-15.04.1998; V. O. Becker, collector; Collection Becker 114619. – 1 male; VBC, without catalogue number; Brazil, Minas Gerais, Caraça, 1300 m; 07-10.05.1996; V. O. Becker, collector; Collection Becker 108099; DNA voucher Lepidoptera B. Landry n° 046. – 1 female; VBC, without catalogue number; Brazil, Minas Gerais, Serra do Cipó; 17-19.04.1991; V. O. Becker, collector; Collection Becker 78017.

Terminal 333 base-pairs of CO1 (DNA voucher Lepidoptera B. Landry n° 046)

RTGGAGCAKGAACTGGATGAACGGTATAC-
CCCCCCCTTTCATCTAATATTGCTCATGGTG-
GTAGATCGGTAGATTTAGCTATTTTTTCCTTA-
CATTTAGCTGGAATTTCTTCAATTTTAGGTG-
CAATTAATTTTATTACAACAATTATTAATATA-
AAAATTAATGGATTATCATTTGATCAAATACCAT-
TATTTGTTTGAGCTGTAGGAATTACAGCCTTAT-
TACTATTGTTATCTTTACCTGTTTTAGCGGGAGC-
TATTACTATACTGCTAACTGATCGAAATTTA-
AATACTTCATTTTTTGACCCAGCTGGGGGAG-
GAGATCCTATTTTATAT

Diagnosis: The wingspan of the holotype is 12 mm (Gaskin, 1986a) and as shown on Fig. 9, the hind wings are dark and the forewing has three white patches and ochre yellow in the fasciae. Males can be darker than the holotype or paler (Fig. 3), but all available males have the same wingspan of 12.0 mm and a similar valva with a longer dorsal section and a ratio of valva length/width of 1.17 (holotype's right valva; the left one being distorted) and 1.20 (one male from Caraça). The males of *Diptychophora ardalia* sp. n. (Fig. 5) can be as dark or darker than the holotype of *D. diasticta*, but they have a shorter wingspan of 11.0 mm at the most and the tip of their maxillary and labial palpi are greyish brown to greyish ochre yellow whereas the tip of the palpi of *D. diasticta* are white. The male genitalia of *D. ardalia* differ most strikingly in the squarish shape of the valva (Fig. 16), which has a ratio of length/width of 1.0. The male genitalia of *D. diasticta* (Figs 11, 12, 14) also have a slightly longer uncus + subscaphium + gnathos complex, especially with respect to *D. planaltina* (Fig. 15), and the uncus in side view differs from that of *D. ardalia* and *D. planaltina* in being wide at base with parallel dorsal and ventral margins until about 1/3, from where it becomes narrower until the apex that is not as flat as in *D. planaltina* and not as thick as in *D. ardalia*. The basal margin of the vinculum medially also differs in the three species with that of *D. diasticta* being broadly rounded, that of *D. planaltina* with only a tiny rounded knob, and that of *D. ardalia* produced and pyramid shaped. Finally, the ratio of the length of the sclerotized section of the phallus shaft over its width (which remains equal from base to apex in the three species) is 4.6 for *D. diasticta*, 6.2 for *D. ardalia*, and 7.5 for *D. planaltina*. In female genitalia this species (Fig. 18) is most similar to *D. planaltina* (Fig. 19), but its papillae anales are smaller, its anterior apophyses are sinuous instead of straight, and only the distal quarter of its corpus bursae is narrower whereas the whole distal half is narrower in *D. planaltina*.

Description of the female: Female (n=3) (Fig. 4). Moths entirely darker than male (Fig. 3), as shown. Forewing length: 6.0 mm; wingspan 13.0 mm. Frenulum with 3 acanthae. Abdominal segment VII about twice as long as preceding segment, narrower, distinctly more thickly sclerotized and thickly scaled along apical margin, with the latter medially concave on sternite, straight on tergite.

Female genitalia (n=1) (Fig. 18). Papillae anales very short, abundantly setose and spinulate, subtriangular in lateral aspect, with setose surface about as long dorsally and ventrally, without apparent apicomedian concavity. Posterior apophysis straight, long, about 2X as long as width of papilla analis, reaching middle of intersegmental membrane VII-VIII in extension. Tergite VIII of medium length, dorsal edge about 20% shorter than width of papilla analis; anterior apophysis of medium length, about 40% shorter than posterior apophysis, distinctly sinuous. Ostium bursae membranous, spinulate, bowl-shaped, slightly wider than long, without sclerotization of sterigma, but lamella postvaginalis lightly spinulate. Ductus bursae without sclerotization or scobination at base and following junction of ductus seminalis, just before mid-length, otherwise scobinate, more thickly so upon reaching corpus bursae, width median, slightly wider beyond mid length. Corpus bursae narrow and elongate, with distal quarter distinctly narrower, reaching abdominal segment I, scobinate at base and slightly beyond signa, otherwise not; with pair of circular signa near base laterally (here shown dorsoventrally).

Remarks: Gaskin (1986a) described this species from the holotype only and provided a right forewing and male genitalia drawings. Photographs are provided here of the habitus, labels, and male genitalia (Figs 9-12). Although the two available males from Caraça (Fig. 3) are paler, they are associated here with *D. diasticta* on the basis of the similar size and male genitalia shape of the valva. Gaskin (1986a) cited the type locality of this species as "Sao Antonio de Barra" in the Province of Bahía. The proper locality name is "Santo Antônio de Barra" (see Fig. 10), now located within the municipality of Salvador de Bahía, the present capital of the state of Bahia and the former capital of Brazil, between 1549 and 1763. The collector of the holotype, Pierre-Emile Gounelle (1850-1914), was a French naturalist who collected insects and plants and published on the Cerambycidae of Brazil (e.g. Gounelle, 1911). A BLAST analysis of the partial CO1 sequence obtained for this species was performed on BOLD

(www.boldsystems.org) by T. Léger on October 24, 2020. It returned a 93.4% similarity with a specimen of an undetermined Crambidae (part of Pyralidae *sensu lato*), followed by a 93.2% similarity with a specimen of *Spilomela personalis* Herrich-Schäffer (Pyralidae *sensu lato*, Spilomelinae), followed by similarities between 92.98% and 93.1% with five specimens of undetermined Gelechiidae. There are no Crambinae in the top 20 matches retrieved, except perhaps the unknown Crambidae, for which the collecting data and image are recorded as 'private,' meaning unpublished, in BOLD.

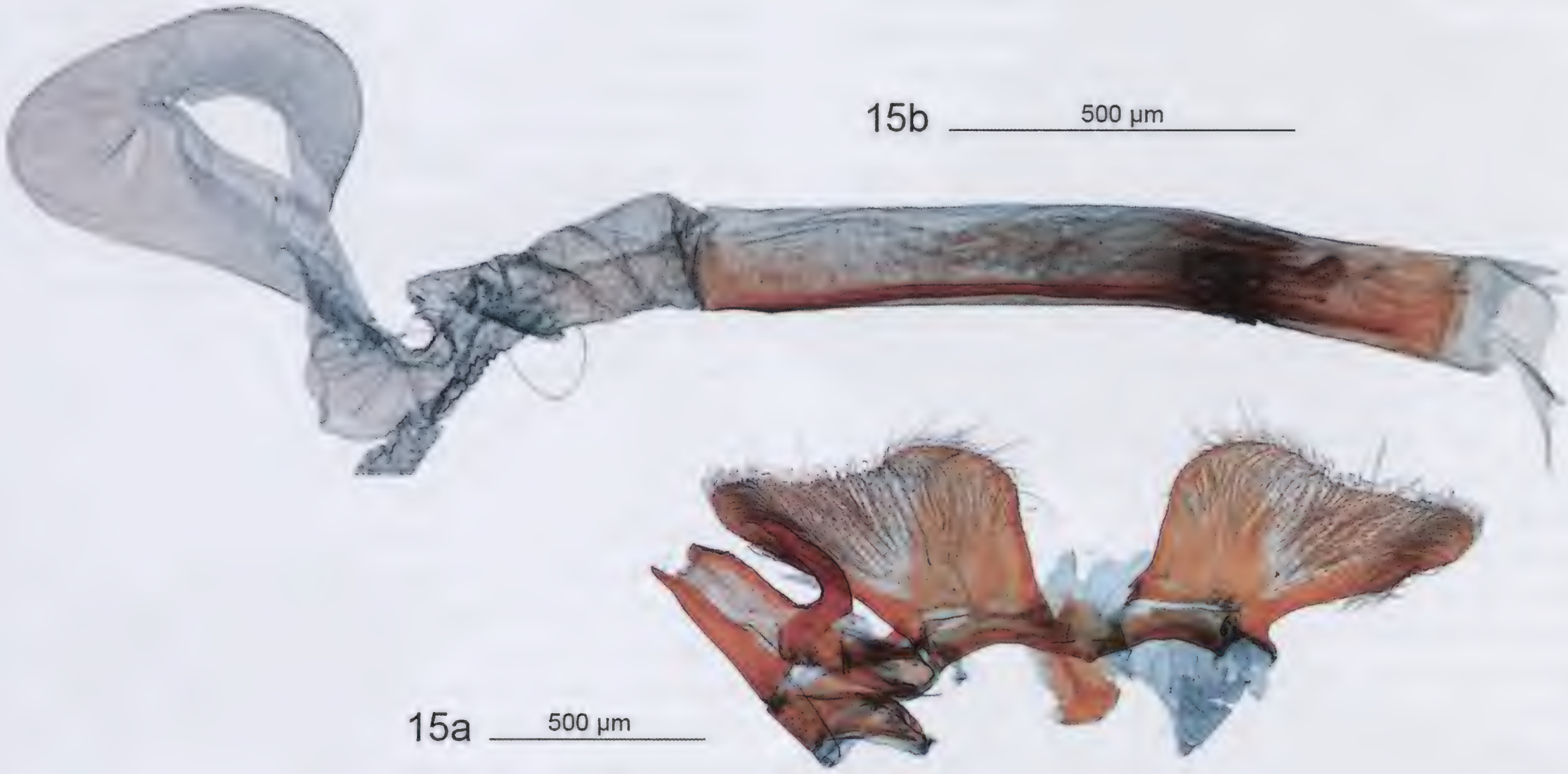
***Diptychophora ardalia* sp. n.**

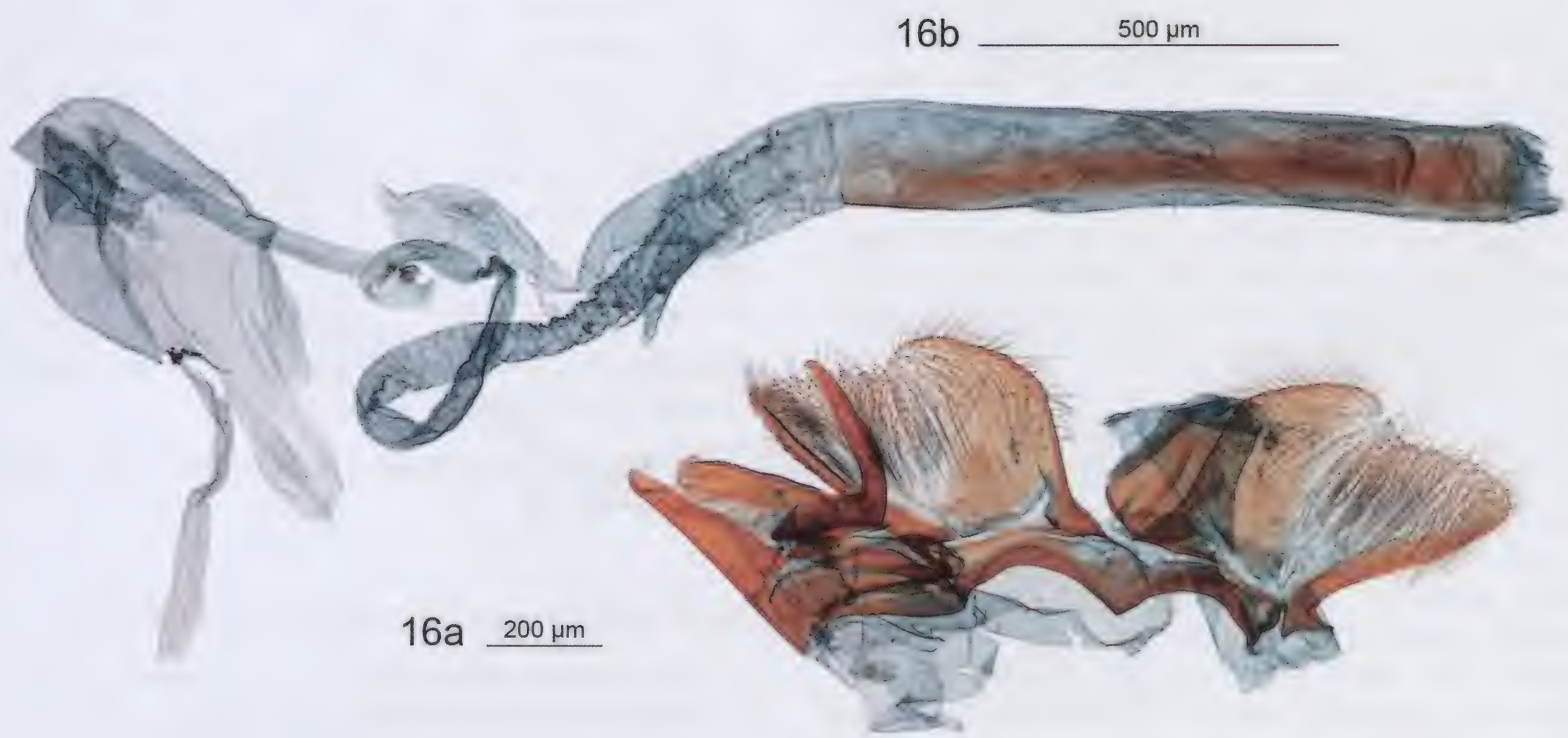
Figs 5, 16

Material examined

Holotype: male; VBC, without catalogue number; Brazil, Bahia, Morro do Chapéu, 1400 m; 22-23.04.1991; V.O. Becker collector; Collection Becker 78261.

Paratypes (7 males): 3 males; VBC, without catalogue number; same data as holotype. – 1 male; MHNG-ENTO-85388 (dissected); same data as holotype; DNA voucher Lepidoptera B. Landry n° 052. – 1 male; VBC, without catalogue number; Brazil, Bahia, Jequié, 600-750 m; 11-22.11.1995; Collection Becker 105724. – 2





Figs 15-16. Male genitalia of *Diptychophora* species, (a) without phallus, (b) phallus. (15) *D. planaltina*. (16) *D. ardalia*.

males; VBC, without catalogue number; Brazil, Bahia, Jequié, 500 m; 16.02.1998; Collection Becker 114384; one with DNA voucher Lepidoptera B. Landry n° 045.

Diagnosis: The males are small, reaching a wingspan of 11.0 mm at the most. In that respect they differ externally from the males of *D. diasticta*, which reach a wingspan of 12 mm. In addition, the tip of the maxillary and labial palpi are greyish brown to light ochre yellow whereas the tip of the palpi is white in *D. diasticta*. In male genitalia, this species conspicuously differs from its congeners in the squarish shape of the valva that reach a ratio of length/width of 1.0 whereas the males of *D. diasticta* have the dorsal section of the valva extended and thus have a ratio of length/width of 1.17-1.20. More diagnostic characters of the male genitalia are given above under the diagnosis of *D. diasticta*.

Etymology: The name refers to the apparent uncleanliness of the moths, "*ardalos*" meaning "dirty" in Greek.

Description: Male (n=7) (Fig. 5). Head with frons rounded, slightly bulging; vestiture on frons short scaled, white and light ochre yellow with large blackish brown spot dorsomedially; vestiture on vertex and occiput with thinner and longer scales ochre yellow. Antennal scape and pedicel blackish brown; flagellomeres with paler, greyish brown scales. Maxillary palpus greyish brown, lighter at base and apex. Labial palpus porrect, reaching slightly beyond maxillary palpus, with scales appressed, basal palpomere white, 2nd and 3rd palpomeres light dirty ochre yellow to greyish brown. Haustellum white. Thorax with patagium laterally white to light ochre yellow to blackish brown toward middle; tegula with patch of blackish brown at base, otherwise white with light yellowish brown to brown; thorax between tegulae greyish brown, then banded dirty white with light ochre yellow, blackish brown, ochre brown, and blackish brown (at apex). Forewing length: 4.4-5.0 mm (holotype: 4.7 mm); wingspan: 10.0-11.0 mm (holotype: 10.5 mm). Wings with pattern and colours as illustrated, with purplish shine in forewing fringe at level of terminal black dots. Prothoracic leg coxa white along base and inner margin, light greyish ochre elsewhere; trochanter light greyish ochre; femur light greyish brown except for white ventral edge; tibia with light greyish brown on basal 2/3 followed by tuft of blackish brown, apically with row of dirty white scales; first tarsomere with basal half dirty white, distal half blackish brown; second tarsomere white; third tarsomere blackish brown with white at base; fourth tarsomere blackish brown; distitarsus blackish brown with dirty white apically. Mesothoracic leg coxa and trochanter white to light yellowish cream; femur white with light greyish brown at tip; tibia greyish brown dorsally on basal half, white to light dirty white elsewhere, with external tibial spur about half as long as internal; first tarsomere mostly dark greyish brown except for dirty white base and white tip; tarsomeres II to V blackish brown at base and white apically. Metathoracic leg coxa, trochanter and femur as mesothoracic leg; tibia white to dirty white, with spurs concolorous and subequal in length; first tarsomere mostly dark greyish brown except for dirty white base and white tip; tarsomeres II to V blackish brown on basal half, white on distal half. Abdomen dorsally dark greyish brown except for patch of ochre brown medially at base and around genitalia; ventrally light greyish brown at base, dark greyish brown on distal 3-4 sternites.

Male genitalia (n=2) (Fig. 16). Uncus + subscaphium + gnathos medium-sized, reaching apex of valva. Uncus of medium width in side view, with ratio of length over width of 2.94, evenly thinning from base until apex; with clear demarcation from tegumen at base; apically thick, not flattened, with ventral concavity. Subscaphium thickly sclerotized, with transversal wrinkles ventrally on distal 3/8. Gnathos with base of distal arm ventrally forming angle slightly wider than 90° with proximal arms, and subsequent curve of ventral edge of distal arm gentle; apically curved upward and reaching tip of subscaphium. Tegumen medium-sized, with posterior lateral arms parallel-margined and about as wide as dorsal connection; anterior plates more than half as narrow as posterior arms, enlarging slightly to point of connection at mid length of lateral arms of gnathos. Valva short, as long as wide (length/width ratio: 1.0); slightly longer dorsal section more abundantly setose along apical third, with dorsal edge only slightly produced beyond middle; ventral section barely produced, with rounded ventroapical margin somewhat truncated. Vinculum very narrow, with basal margin medially distinctly produced, pyramid shaped. Phallus a long, straight, narrow tube, slightly more than twice as long as valva, with sclerotized shaft about 6.2 times longer than wide, with thickly sclerotized ventral strut of medium width, enlarging apically to twice its width; vesica with one spinulate section.

Female genitalia: unknown.

Biology: Unknown, except that the two localities are in the dry Caatinga Biome.

Distribution: The species is known from the eastern, coastal Brazilian state of Bahia only.

Remark: The holotype is missing the right mesothoracic leg.

LIST OF THE BRAZILIAN *DIPTYCHOPHORA*

- *Diptychophora ardalia* sp. n. (Fig. 5). Described above from males collected in the state of Bahia.
- *Diptychophora diasticta* Gaskin, 1986 (Figs 3, 4). Described from a single male from the state of Bahia

(NHMUK). The female genitalia are described above from additional material collected in the state of Minas Gerais.

- *Diptychophora galvani* sp. n. (Fig. 8). Described above from the states of Minas Gerais and Mato Grosso.
- *Diptychophora kuhlweinii* Zeller, 1866 (Fig. 2). (Misspelled '*kuhlweini*' by Gaskin (1986a). Described from Rio de Janeiro, the holotype could not be recovered as mentioned by Gaskin (1986a). Gaskin (1986a) mentions specimens examined from the states of Paraná, Rio de Janeiro, and Santa Catarina. We have examined additional material from Bahía (Reserva Serra Bonita) and Minas Gerais (Caraça).
- *Diptychophora planaltina* sp. n. (Figs 6, 7). Described above from the Federal District.
- *D. subazanalis* Błeszyński, 1967 (Fig. 1). Described as a subspecies of *Steneromene azanalis* (Walker, 1859), it was rightfully given species status by Gaskin

Figs 17-19. Female genitalia of *Diptychophora* species. (17) *D. galvani*. (18) *D. diasticta*. (19) *D. planaltina*.

(1986a). Described from Surinam (holotype in CUIC), this species was reported from the Brazilian state of Pernambuco by Gaskin (1986a). We have examined additional material from the states of Goiás (Alto Paraíso, 1400 m), Minas Gerais (Unaí, 700 m), Pará (Capitao Poco), and Rondônia (Ariquemes, 180 m; Cacaulândia, 140 m; Porto Velho, 180 m), all in VBC. The species is also known from Bolivia (Santa Cruz, MHNG), Ecuador (Napo, VBC), French Guiana (MHNG), Guyana (Błeszyński, 1967; Gaskin, 1986a), and Peru (Gaskin, 1986a).

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REFERENCES

Błeszyński S. 1967. Studies on the Crambinae (Lepidoptera). Part 44. New Neotropical genera and species. Preliminary check-list of Neotropical Crambinae. *Acta Zoologica Cracoviensia* 12(5): 39-110.

Dognin P. 1905. Hétérocères nouveaux de l'Amérique du Sud. *Annales de la Société Entomologique de Belgique, Bruxelles* 49: 61-90.

Gaskin D.E. 1986a. Genus *Diptychophora* Zeller and a related new genus *Steneromene* from the Neotropical Region (Pyralidae: Crambinae). *Journal of the Lepidopterists' Society* 40(2): 107-123.

Gaskin D.E. 1986b. New genera for the Neotropical "*Pareromene*" species (Pyralidae: Crambinae). *Journal of the Lepidopterists' Society* 40(4): 271-288.

Gaskin D.E. 1989. *Neoeromene lutea* (Lepidoptera: Pyralidae; Crambinae), a new species from Brazil. *Journal of the Lepidopterists' Society* 43(4): 323-326.

Gounelle E. 1911. Liste des Cérambycides de la région de Jatahy, Etat de Goyaz, Brésil. 2e partie. *Annales de la Société entomologique de France* 80: 1-150.

Hampson G. F. 1895. On the Geometridae, Pyralidae, and allied families of Heterocera of the Lesser Antilles. *Annals and Magazine of Natural History, including Zoology, Botany and Geology, London* (ser. 6) 16: 329-349.

Landry B. 1990. Two new species of *Diptychophora* from Mexico (Lepidoptera: Pyralidae: Crambinae: Diptychophorini). *The Canadian Entomologist* 122(11-12): 1071-1077.

Landry B., Andriollo T. 2020. A review of the genus *Microcrambus* Błeszyński, 1963 (Lepidoptera, Pyraloidea, Crambinae) in Colombia, with descriptions of two new species. *Revista U.D.C.A Actualidad & Divulgación Científica* 23(2): e1628. https://doi.org/10.31910/rudca.v23.n2.2020.1628

Léger T., Landry B., Nuss M. 2019. Phylogeny, character evolution and tribal classification in Crambinae and Scopariinae (Lepidoptera, Crambidae). *Systematic Entomology* 44: 757-776.

Léger T., Mally R., Neinhuis C., Nuss M. 2021. Refining the phylogeny of Crambidae with complete sampling of subfamilies (Lepidoptera, Pyraloidea). *Zoologica Scripta* 50(1): 84-99.

Meyrick E. 1938. New Species of New Zealand Lepidoptera. *Transactions and Proceedings of the Royal Society of New Zealand* 67: 426-429.

Nuss M., Landry B., Mally R., Vegliante F., Tränkner A., Bauer F., Hayden J., Segerer A., Schouten R., Li H., Trofimova T., Solis M. A., De Prins J., Speidel W. 2003-2020. *Global Information System on Pyraloidea*. www.pyraloidea.org. Last accessed 01/05/2020.

Solis M. A. 2009. Transfer of all Western Hemisphere Cybalomiinae to other subfamilies (Crambidae: Pyraloidea: Lepidoptera): *Elusia* Schaus, *Dichochroma* Forbes, *Schacontia* Dyar, *Cybalomia extorris* Warren, and *C. lojanalis* (Dognin). *Proceedings of the Entomological Society of Washington* 111(2): 493-504.

Walker F. 1859. Pyralides. *List of the Specimens of Lepidopterous Insects in the Collection of the British Museum, London* 19: 799-1036.

Zeller P.C. 1866. Beschreibung einiger amerikanischen Wickler und Crambiden. *Stettiner Entomologische Zeitung* 27(4-6): 137-157.

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Etude biométrique du Scinque officinal ou « poisson de sable » *Scincus scincus* (Linnaeus, 1758) : analyse du dimorphisme sexuel de la sous-espèce *S. s. scincus* (Linnaeus, 1758) de la région d'El Oued Souf (Algérie)

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Résumé : Le Scinque officinal ou Poisson de sable *Scincus scincus* (Linnaeus, 1758) (Scincidae : Squamata) est un lézard qui a une aptitude à se mouvoir dans les sables du désert particulièrement remarquable. Il a fait l'objet d'études anatomo-fonctionnelles en lien avec sa locomotion originale, ainsi que récemment d'études sur sa valeur nutritionnelle comme source de protéines animales, mais à ce jour, aucun travail sur la biométrie ou sur le dimorphisme sexuel de cette espèce n'a été publié. Cette étude de la morphométrie externe de l'animal repose sur 100 individus adultes (50 mâles et 50 femelles) de la sous-espèce *Scincus scincus scincus* (Linnaeus, 1758) récupérés dans la région de El Oued Souf (Algérie) et vise à caractériser le dimorphisme sexuel de l'espèce. En plus du poids vif des individus, 11 paramètres linéaires ont été mesurés par animal et 3 indices de forme ont été calculés. Pour chaque variable, une valeur seuil permettant de discriminer au mieux les mâles des femelles est proposée. Le modèle linéaire généralisé multivarié le plus discriminant intègre CT (le périmètre thoracique), T (la longueur de la tête) et LmP (la longueur du membre pelvien). Cependant, la mesure T, considérée seule, discrimine avec un faible taux d'erreur.

Mots-clés : Morphométrie - paramètres linéaires - poids vif - indices de forme.

Abstract : Biometrical study of the Common Skink or Common Sandfish *Scincus scincus* (Linnaeus, 1758) : analysis of the sexual dimorphism of the sub-species *S. s. scincus* (Linnaeus, 1758) from the region of El Oued Souf (Algeria). - The Common Skink or Common Sandfish *Scincus scincus* (Linnaeus, 1758) (Scincidae : Squamata) is a lizard that has a particularly remarkable ability to move in the desert sands. It has been the subject of anatomo-functional studies in connection with its original locomotion, as well as recent studies on its nutritional value as a source of animal proteins. To date, no work has been published on biometrics or sexual dimorphism of this species. This study of the external morphometry of the animal is based on 100 adult individuals (50 males and 50 females) of the sub-species *Scincus scincus scincus* (Linnaeus, 1758) collected in the region of El Oued Souf (Algeria) and aims to characterize the sexual dimorphism of the species. In addition to the live weight of individuals, 11 linear parameters were measured per animal and 3 form indexes were calculated. For each variable, a threshold value is proposed to best discriminate between males and females. The most discriminating multivariate generalized linear model integrates CT (Chest circumference), T (Head length) and Lmp (Pelvic limb length). However, the T measurement, considered alone, discriminates with a low error rate.

Keywords : Morphometry - linear parameters - live weight - form indexes.

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INTRODUCTION

Le Scinque officinal ou Poisson de sable, du genre *Scincus* et de l'espèce *Scincus scincus* (Linnaeus, 1758), est un lézard (Arnold & Leviton, 1977) qui fait partie de la famille des Scincidae appartenant à l'ordre des Squamata. Cette espèce est composée de 4 sous-espèces : *Scincus scincus conirostris*, Blanford, 1881, *Scincus scincus cucullatus*, Werner, 1914, *Scincus scincus meccensis*, Wiegmann, 1837 et *Scincus scincus scincus* (Linnaeus, 1758). Deux sous-espèces sont majoritairement représentées en Algérie *S. s. cucullatus* (Benhaoua & Khaldi, 2019) et la forme nominotypique *S. s. scincus* qui a donné lieu à ce travail. En terme de diversité, les Scincidae constituent plus du quart de la diversité mondiale des lézards avec quatre sous-familles (Acontinae, Mabuyinae, Lygosominae et Scincinae), la dernière renfermant à elle seule 33 genres. Le genre *Scincus* décrit par Laurenti en 1768 est considéré comme un groupe monophylétique (Whiting *et al*., 2003 ; Whiting, 2004), et renferme quatre espèces [*S. albifasciatus*, Boulenger, 1890 ; *S. hemprichii*, Wiegmann, 1837 ; *S. mitranus* Anderson, 1871 et celle étudiée ici, *S. scincus* (Linnaeus, 1758)]. L'extension géographique du Scinque officinal est nord-africaine (du Sénégal au Soudan, en passant par la Mauritanie, le Mali, le Nigéria, le Niger, l'Algérie, le Maroc, la Tunisie, la Lybie, et l'Egypte) et moyenne orientale (de la Palestine à l'Iran, en passant par la Jordanie, la Syrie, l'Arabie saoudite, le Yémen, les Emirats arabes unis, le Qatar, Bahreïn, le Koweït, et l'Irak). L'Iran semble la marge la plus orientale de l'aire de répartition (Sindaco, 1998 ; Shafiei *et al*., 2015). Cet animal a une aptitude à se mouvoir dans les sables du désert (dans les dunes) particulièrement remarquable. Il disparaît sous le sable rapidement (moins d'une seconde) en cas de danger et progresse par des ondulations du corps (Arnold & Leviton, 1977) qui lui ont valu son nom de poisson de sable. Il a fait l'objet d'études anatomo-fonctionnelles (Russel & Bels, 2001 ; Baumgartner *et al*., 2008 ; El-Bakry *et al*., 2012 ; Sharpe *et al*., 2013 ; Stadler *et al*., 2016 ; Wu *et al*., 2018 ; Gadel-Rab *et al*., 2018), en lien avec sa locomotion originale et sa progression sous le sable, ainsi que récemment d'études sur sa valeur nutritionnelle, comme source de protéines animales (Salem *et al*., 2017 ; Toumi *et al.,* 2017). Le Scinque a été à l'origine d'études anatomiques ou histologiques (Hetherington, 1989 ; El-Bakry *et al*., 2012 ; Salem *et al*., 2017 ; Abo-Eleneen *et al*., 2014), mais à ce jour, aucun travail sur la biométrie ou sur le dimorphisme sexuel de cette espèce n'a été publié.

MATÉRIEL ET MÉTHODES

Matériel biologique

Un échantillon de 100 Scinques adultes (50 mâles et 50 femelles) appartenant à la sous-espèce *Scincus scincus scincus* (Linnaeus, 1758) a été constitué par prélèvement dans le milieu extérieur, par ramassage à la main dans la région d'El Oued Souf, au nord-est du Sahara algérien, au sud-sud-est de la Willaya de Ouargla. Cette espèce fait partie de la faune sauvage non protégée d'Algérie et est couramment exploitée en complément de l'alimentation humaine. Le dimorphisme sexuel est visible extérieurement (les femelles ayant une couleur plus terne qui se rapproche de la livrée juvénile, alors que les mâles présentent des marques noires nettes) et a permis le sexage (Fig. 1).

Méthodes

Mesures

Le poids vif (PV, masse) de chaque individu a été déterminé à l'aide d'une balance alimentaire (Zenati Electronics, précision le 1/10 g) et noté PV. Les 9 mesures linéaires ont été réalisées à l'aide d'un pied à coulisse (*Electronic Digital Caliper*, dont la précision au 1/100 mm a été réduite au 1/10 mm), et les deux périmètres du tronc de l'animal en utilisant un mètre ruban précis au millimètre. Ces mesures sont représentées sur la Figure 2.

Calcul des indices morphologiques

Afin de s'affranchir de l'effet taille des mesures précédentes, trois indices notés I ont été calculés :

- I1 traduit la taille relative de la tête par rapport à la longueur du corps de l'animal (queue exclue) :

$$I_1 = \frac{T}{Ls}$$

- I2 traduit la longueur relative de la queue par rapport à la taille de l'animal :

$$I_2 = \frac{LT - Ls}{Ls}$$

- I3 traduit la taille relative du tronc en regard du thorax, par rapport à la longueur du corps de l'animal :

$$I_3 = \frac{CT}{Ls}$$

Les trois variables précédentes, qui décrivent des indices morphologiques, ont été intégrées à l'ensemble des données pour le traitement statistique.

Analyse statistique

Pour l'ensemble du travail, les calculs ont été réalisés avec le logiciel R, et la librairie « Factominer » a été utilisée pour les analyses multivariées. Le seuil de significativité retenu est de 0,05. Toutes les variables sont des variables quantitatives [pondérale (en g), linéaires (en mm), et indices sans unité].

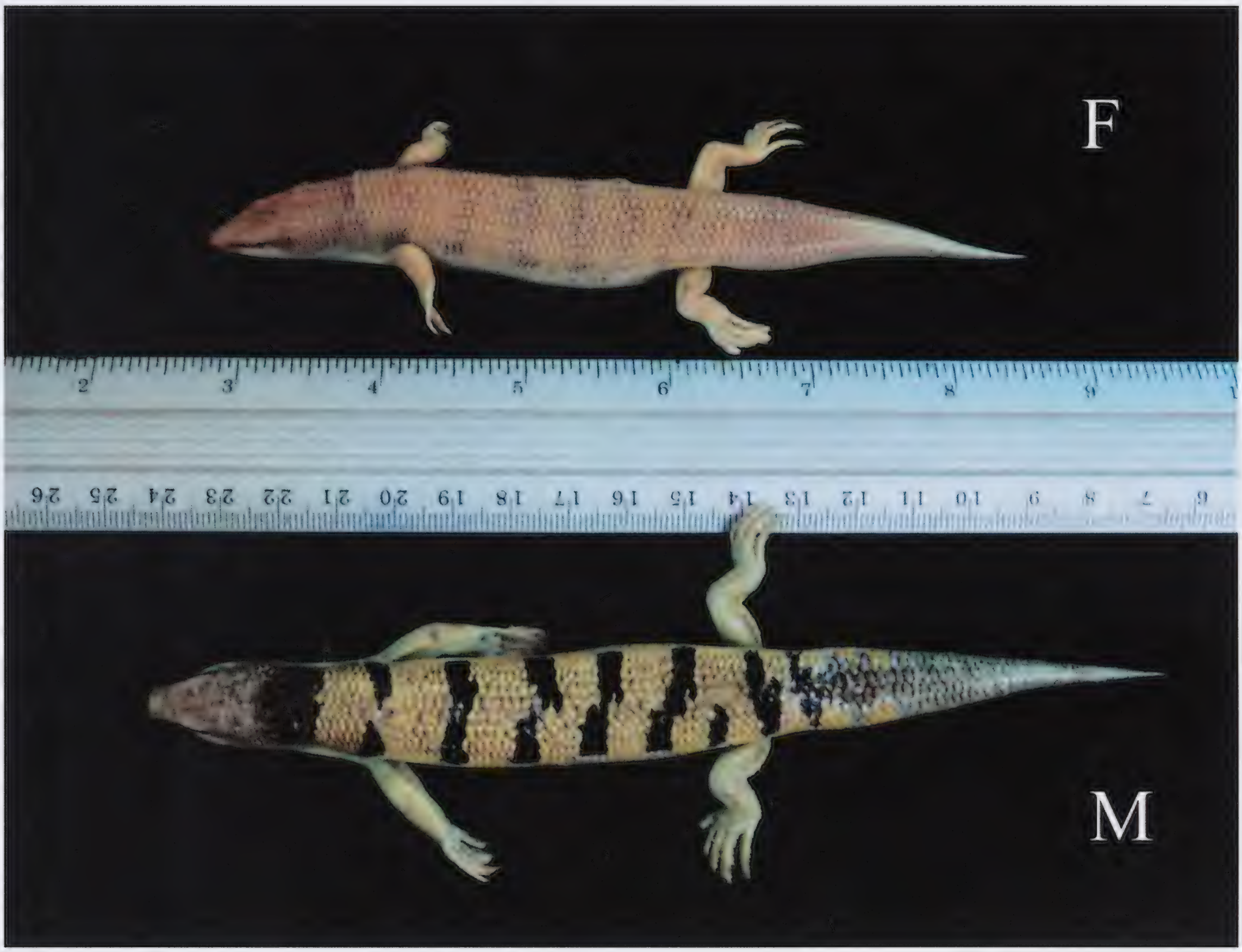

Fig. 1 : Morphologie externe du Scinque (*Scincus scincus*) en vue dorsale. M : mâle, F : femelle.

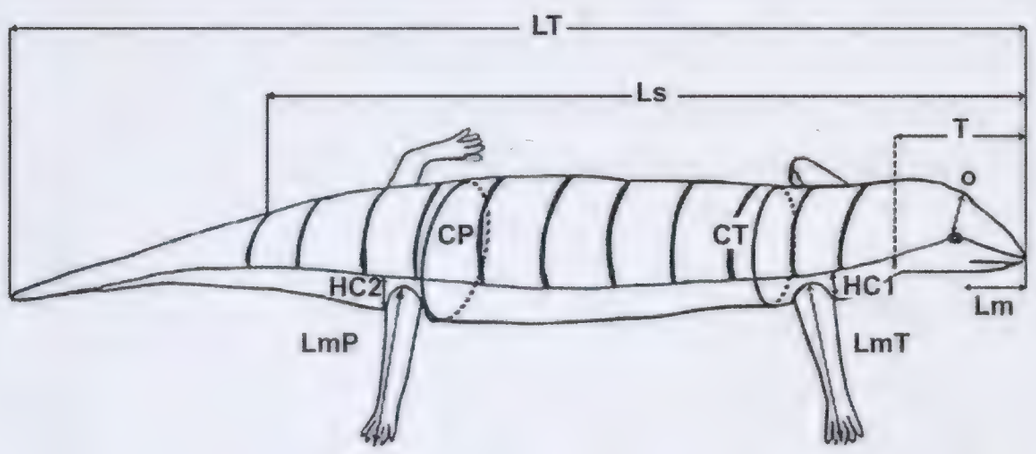

Fig. 2 : Visualisation des mesures linéaires réalisées (*Scincus scincus*, vue latérale droite).
LT : longueur totale, **LS** : longueur standard, **T :** longueur de la tête, **O :** distance inter-orbitaire, **HC1 :** hauteur du corps – thoracique, **HC2 :** hauteur du corps - pelvien, **Lm :** longueur du museau, **CT** : circonférence thoracique, **CP** : circonférence pelvienne, **LmT :** longueur du membre thoracique, **LmP** : longueur du membre pelvien.

Chaque variable (mesure ou indice) du jeu de données a été résumée pour chaque genre (mâles d'une part et femelles d'autre part) par cinq paramètres : minimum (min), maximum (max), moyenne (Moy.), écart-type (σ) et coefficient de variation (C.V. = [σ/Moy.] x 100) dans le Tableau 1 de la partie résultats. Une analyse bivariée a été réalisée entre chaque couple de variables à partir des coefficients de corrélation.

Pour chaque variable, les moyennes des mâles et des femelles ont été comparées par un test de Student précédées d'un test de Fisher pour comparaison des variances. En cas de variances différentes entre les deux échantillons, la correction de Welch a été mise en œuvre. La caractérisation du dimorphisme sexuel a été étudiée, dans un premier temps, par une analyse en composantes principales. Les mesures présentant une différence significative entre les moyennes des mâles et des femelles ont été intégrées comme variables actives, le sexe a été intégré comme variable supplémentaire. Dans une deuxième approche, une analyse du dimorphisme a été tentée par un modèle multivarié linéaire généralisé. Pour les variables les plus discriminantes, une recherche de la

valeur discriminante et de la performance du modèle a été mise en œuvre. Ainsi, considérant que pour une mesure observée inférieure à la valeur discriminante le modèle prédit une femelle et un mâle dans le cas contraire, le taux d'individus mal classés par le modèle a pu être calculé.

RÉSULTATS

Statistiques descriptives

Pour l'ensemble des variables, la valeur moyenne des mâles est plus importante que celle des femelles (Tab. 1), ce qui traduit non seulement une différence de taille des individus mâles par rapport aux femelles, mais aussi de forme, puisque les trois indices sont indépendants de la taille. Pour le Coefficient de variation C.V., on constate que le poids vif présente une plus grande variabilité que les variables linéaires, avec un CV qui va de 31,3 % pour les mâles à 50,7 % pour les femelles, alors que les autres variables oscillent entre 9,6 % et 28,4 %, avec une valeur moyenne de CV de 16,7 %.

Les différences entre les deux sexes sont hautement significatives ($p<0,05$), sauf pour I2 et I3.

L'ensemble des coefficients de corrélation apparaît regroupé dans le Tableau 2. Les variables les mieux corrélées sont d'une part les périmètres thoracique et pelvien, respectivement CT et CP (r=0,91) et d'autre part les longueurs des membres thoraciques et pelviens, LmT et LmP (r=0,90). Le poids vif de l'animal est également bien corrélé avec les variables précédentes, ainsi qu'avec les autres mesures de taille. Les indices de forme I sont peu, voire pas ou très mal corrélés avec les paramètres de taille.

L'analyse multivariée réalisée sur les 15 variables initiales (Fig. 3) démontre que les mesures sont fortement corrélées entre elles. Par conséquent l'ACP présente un « effet taille ». Pour tenir compte de cette propriété, seules les variables CT, HC1, LT, LmP, PV, T, I1 et I2 mesurant

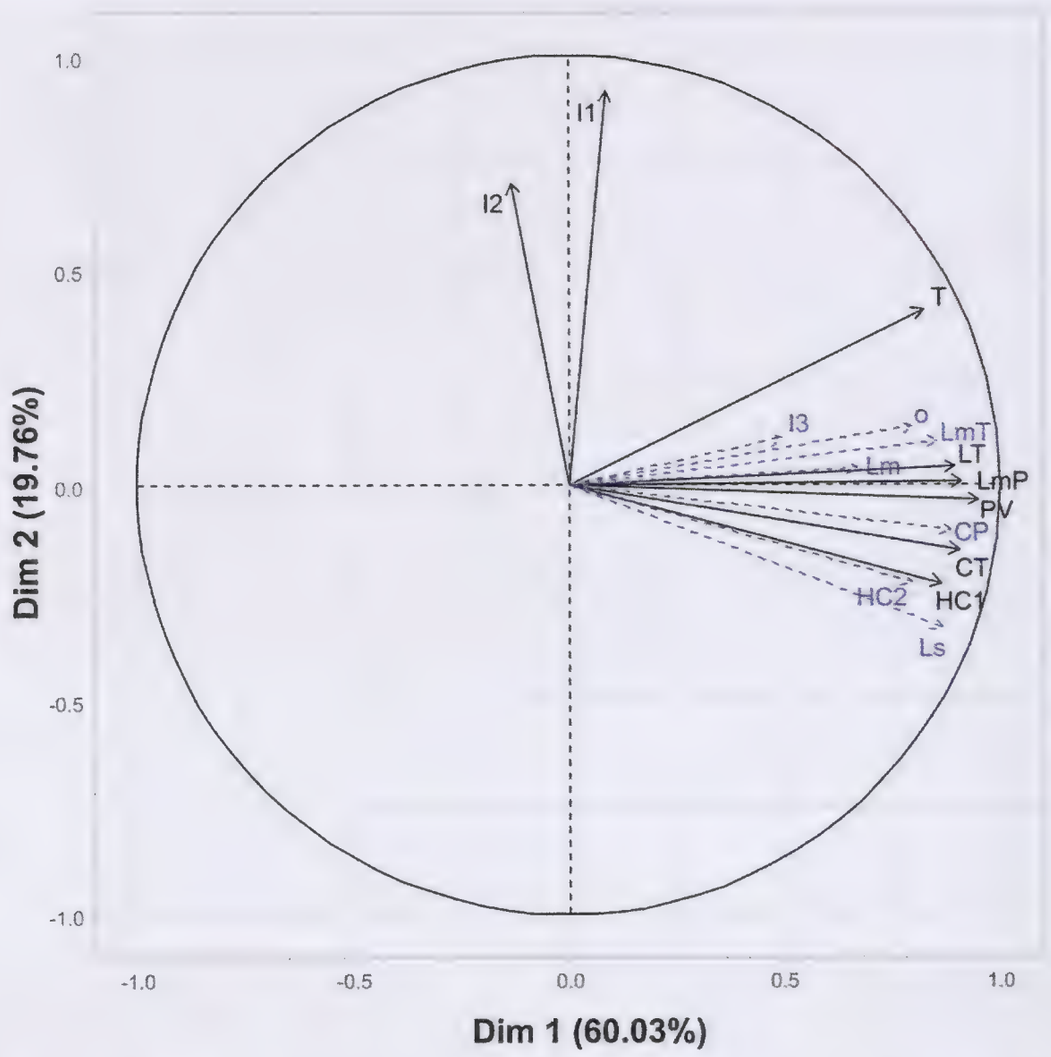

Fig. 3 : ACP (15 variables), plan factoriel principal, graphe des variables. En noir (PV, LT, LmP, CT, HC1, T, I1, I2), les variables actives ; en bleu (I3, O, LmT, Lm, CP, HC2, Ls) les variables supplémentaires.

des caractéristiques morphologiques différentes ont été retenues comme variables actives. Les autres ont été intégrées en variables supplémentaires. Dans cette dernière configuration (uniquement les 8 variables actives), l'axe 1 peut être interprété comme l'axe des mesures morphométriques (axe de taille) et porte 68,41 % de l'inertie totale. L'axe 2 peut être interprété comme l'axe des indices (axe de forme) et porte 18,95 % de l'inertie totale (Fig. 4). Le nuage de points (Fig. 5) montre une certaine ségrégation des mâles et des femelles sur le premier plan factoriel et les ellipses de confiance à 95 % construites autour des points moyens des mâles et des femelles sont clairement disjointes (Fig. 4).

Tableau 1 : Valeurs des paramètres mesurés et des indices calculés pour chaque sexe.

		PV (g)	LT (mm)	Ls (mm)	T (mm)	O (mm)	HC1 (mm)	HC2 (mm)	Lm (mm)	CT (mm)	CP (mm)	LmT (mm)	LmP (mm)	I1	I2	I3
Mâles	min	11,1	122,0	70,1	12,9	6,2	8,2	6,5	10,5	32	29	19,3	27,5	0,15	0,34	0,39
	max	57,8	196,0	129,7	29,5	10,5	20,8	17,0	20,3	79	63	36,8	40,9	0,25	0,88	0,62
	Moy	25,4	159,4	101,6	19,6	8,7	13,7	11,2	15,2	51	43	28,6	33,0	0,19	0,57	0,5
	σ	8,0	16,8	11,7	3,3	0,9	2,4	2,0	2,2	9	7	3,2	3,2	0,02	0,12	0,06
	C. V.	31,3	10,5	11,5	16,8	10,9	17,4	17,7	14,5	17,0	15,8	11,0	9,6	10,6	20,0	12,0
Femelles	min	7,3	101	62,2	12,2	5,1	6,2	5,4	11,0	30	26	17,0	21,5	0,12	0,23	0,33
	max	38,3	177,0	141,2	20,5	9,2	20,0	16,7	17,1	68	55	28,8	36,2	0,24	0,9	0,74
	Moy	16,4	137,4	88,6	15,1	7,3	11,8	10,1	13,6	44	37	23,0	27,6	0,17	0,56	0,49
	σ	8,3	20,7	16,2	1,8	1,1	3,2	2,6	1,8	12	9	3,6	4,4	0,03	0,15	0,09
	C. V.	50,7	15,0	18,3	12,0	15,1	27,2	26,1	13,1	27,4	24,7	15,8	15,9	15,6	26,2	18,1
t-Test	p-value	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	0,0004	0,0088	0,0001	0,0006	0,0002	<0,0001	<0,0001	<0,0001	0,3489	0,2500

Tableau 2 : Valeurs des coefficients de corrélation de Pearson entre chaque couple de variable, pour l'ensemble de la population. Gris italique : ns. Noir italique : 0,0001<p<0,05. Noir : p<0,0001. En gras : r>0,79.

	PV													
LT	**0,81**	**LT**												
Ls	**0,80**	**0,85**	**Ls**											
T	0,75	0,73	0,68	**T**										
o	0,72	0,74	0,69	0,76	**o**									
HC1	**0,83**	0,71	0,73	0,55	0,56	**HC1**								
HC2	0,78	0,66	0,67	0,48	0,56	**0,89**	**HC2**							
Lm	0,65	0,58	0,54	0,55	0,54	0,58	0,54	**Lm**						
CT	**0,86**	0,76	0,77	0,62	0,67	**0,82**	0,78	0,59	**CT**					
CP	**0,88**	0,75	0,74	0,62	0,65	**0,80**	**0,80**	0,62	**0,91**	**CP**				
LmT	0,78	0,77	0,74	0,77	**0,81**	0,65	0,63	0,58	0,70	0,72	**LmT**			
LmP	**0,82**	**0,82**	0,79	0,73	**0,80**	0,72	0,67	0,64	0,78	0,77	**0,90**	**LmP**		
I1	*0,07*	*-0,03*	*-0,24*	0,54	*0,20*	*-0,13*	*-0,14*	*0,11*	*-0,05*	*-0,02*	*0,18*	*0,07*	**I1**	
I2	*-0,15*	*0,07*	-0,45	*-0,07*	*-0,09*	*-0,18*	*-0,16*	*-0,06*	*-0,17*	*-0,13*	*-0,11*	*-0,11*	0,40	**I2**
I3	0,49	*0,29*	*0,15*	*0,24*	*0,33*	0,49	0,50	0,34	0,74	0,65	*0,34*	0,40	*0,16*	*0,21*

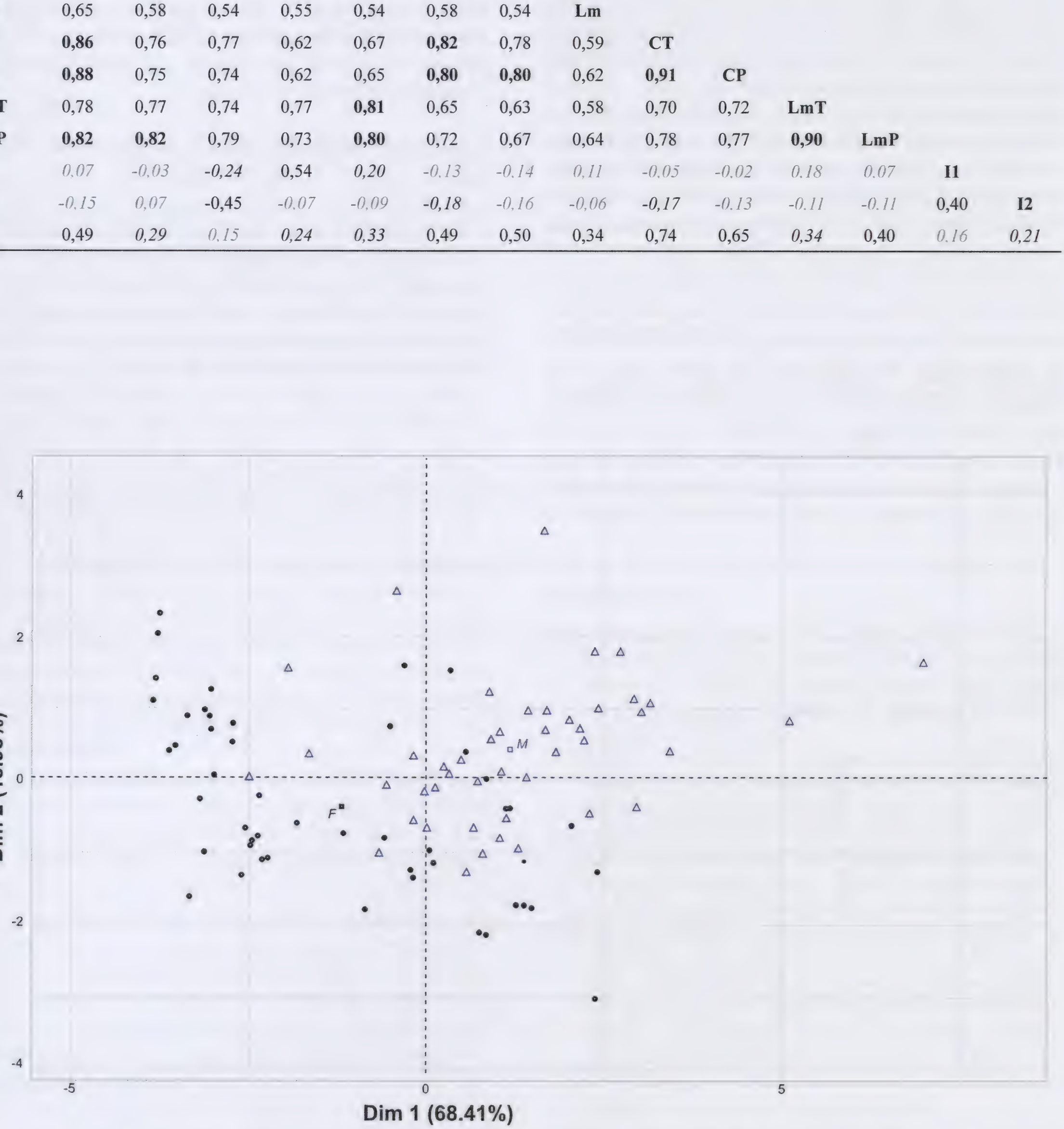

Fig. 4 : ACP (8 variables), plan factoriel principal, graphe des individus. Les mâles sont indiqués en bleu, les femelles en noir.

La séparation entre les mâles et les femelles se fait principalement sur l'axe 1 de l'ACP, mais il existe une continuité biologique entre les deux populations et les plus grandes femelles ont des valeurs voisines de celles des plus petits males.

Etude et Modélisation du dimorphisme sexuel

Comme mentionné précédemment, la comparaison des moyennes des mâles et des femelles pour chaque variable réalisée par un test de Student (t-Test) montre une différence significative pour toutes les mesures et l'indice I1. Les moyennes des indices I2 et I3 ne sont pas significativement différentes (Tab. 1).

Connaissant les valeurs mesurées pour les variables utilisées comme variables actives dans l'ACP, la probabilité de prédire un mâle a été évaluée par un modèle linéaire généralisé (prédiction d'une variable à deux modalités, le sexe, en fonction des mesures). Par la suite une sélection du meilleur modèle (critère de l'AIC ou Critère d'Information d'Akaike le plus faible) a été mise en œuvre par une méthode pas à pas ascendante et descendante. Par une procédure pas à pas descendante, la combinaison des variables CT, T et LmP a été identifiée comme apportant le plus d'informations pour la prédiction du sexe. En revanche par une procédure pas à pas ascendante, seule la variable T a été retenue.

Reprenant les résultats des t-tests, dans la mesure où chaque variable discrimine les deux sexes, un modèle linéaire généralisé a été construit pour chacune des trois variables CT, T et LmP (formules : Sexe ~ CT, Sexe ~T, Sexe ~LmP). La valeur discriminante de cette mesure a été calculée ainsi que le taux de mauvais classement pour chacun de ces modèles. Cette étude a aussi été menée pour le PV, mesure facile à relever et pour l'indice I1 (Tab. 3). La valeur discriminante obtenue s'interprète facilement : pour toute mesure supérieure à cette valeur on prédira un mâle, pour toute valeur inférieure à cette mesure on prédira une femelle. Le taux d'erreur du modèle s'obtient par le rapport :

$$\frac{\text{Nombre de femelles mal classées + Nombre de mâles mal classés}}{\text{Effectif total}}$$

On remarquera que la variable T est celle qui discrimine avec le taux d'erreur le plus faible, ce qui est cohérent avec les résultats des procédures de sélection de modèle cités plus haut. Par ailleurs le modèle retenant les variables CT, T et LmP, reconnu comme le plus discriminant, classe les animaux avec un taux d'erreur de 14 %.

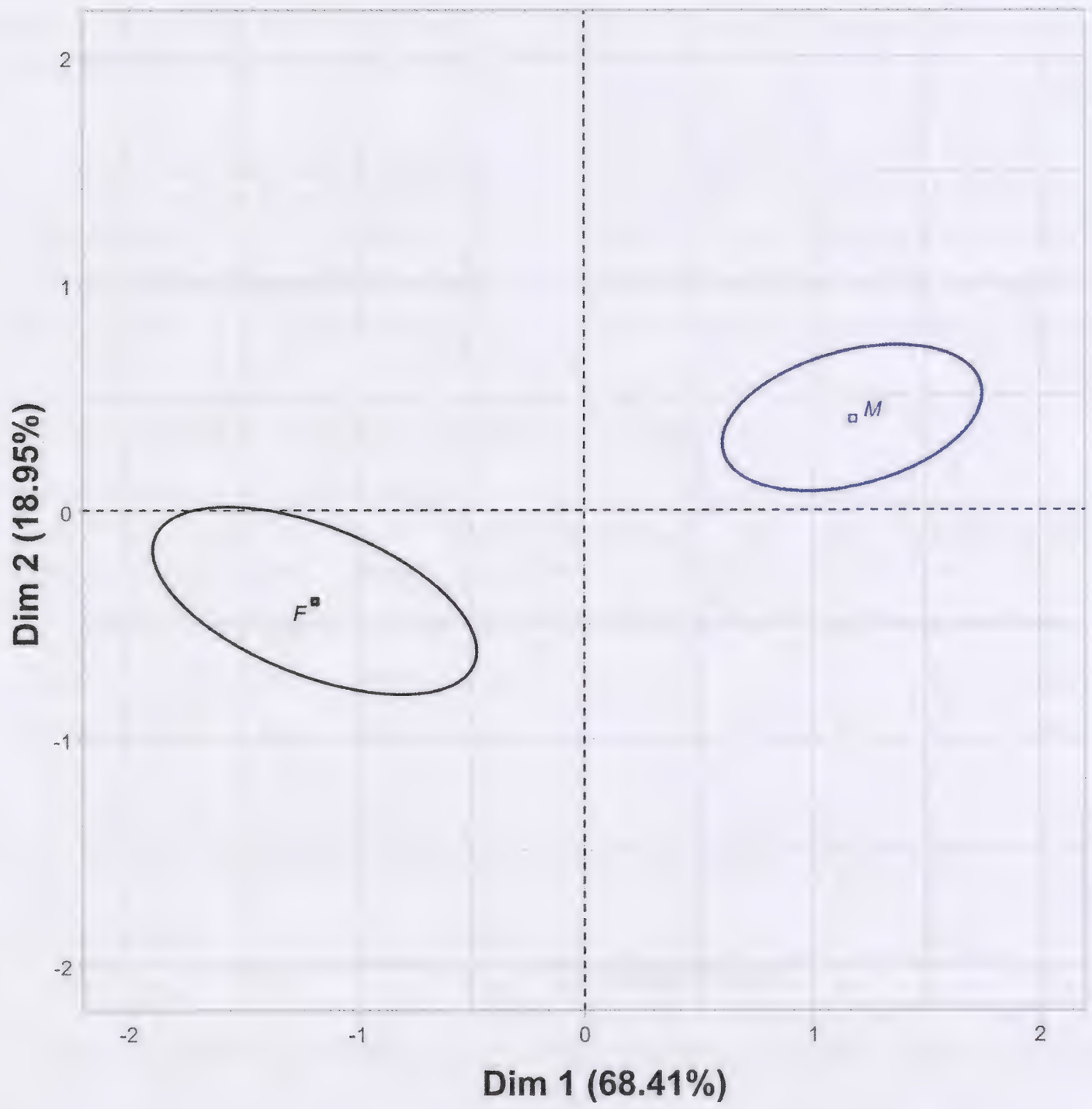

Fig. 5 : ACP (8 variables), plan factoriel principal, graphe des individus (ellipses de confiance 95 %, des mâles et des femelles).

Tableau 3 : Valeurs discriminantes entre mâles et femelles et taux de reclassement selon le modèle linéaire généralisé, pour CT, T, LmP, PV et I1.

Mesure	Valeur discriminante	Taux de mauvais classement
CT	47,2	0,38
T	16,96	0,17
LmP	30,53	0,27
PV	20,6	0,23
I1	0,184	0,35

DISCUSSION

Parmi les Scincidae, de nombreux lézards ne sont pas dimorphiques extérieurement. Dans l'espèce étudiée (*Scincus scincus*), non seulement on retrouve un dimorphisme au niveau de la couleur de l'épiderme, mais cette étude met en évidence un dimorphisme de taille et de forme des animaux. Les mâles sont non seulement plus grands, mais aussi plus massifs et leur tête et leur cage thoracique représentent une proportion plus importante de l'ensemble du corps. Il serait intéressant de vérifier si l'anatomie interne est également modifiée, puisque certains auteurs mentionnent des différences portant par exemple sur l'absence de gras au niveau inguinal chez le mâle, contrairement à la femelle, chez *Ctenotus fallen*, le gras du mâle se localisant au niveau de la queue en lien avec les combats (Pianka & Vitt, 2003). Les auteurs précédents mentionnent également une musculature des mâchoires plus forte chez les mâles dans les espèces suivantes : *Ameiva ameiva*, *Dracaena guianensis*, *Tupinambis merianae* et *Tupinambis duseni*. Les différences observées dans ce travail ne sont pas aussi accentuées chez les juvéniles et c'est une raison pour laquelle cette étude a porté exclusivement sur des animaux adultes.

Cette espèce d'intérêt alimentaire a été décrite par Toumi *et al.* (2017) afin de caractériser la composition de la viande ou de la farine provenant du Scinque officinal. Sur 600 individus jeunes, la valeur moyenne de la longueur du corps était de 12,2 cm ± 4,4 cm et du poids de 20,1 g ± 10,3 g. Ces valeurs recoupent celles de notre étude, en étant situées vers les plus basses, ce qui va dans le sens d'animaux jeunes. Le dimorphisme sexuel n'ayant pas été pris en considération dans le travail de Toumi *et al.* (2017), il n'est pas possible de savoir si les plus faibles valeurs ne peuvent pas également être liées à une sur-représentation des femelles.

CONCLUSION

Cette étude a permis de caractériser la biométrie d'une population de Scinque officinal (*Scincus scincus*) et de préciser le dimorphisme sexuel chez les individus adultes, au-delà de la simple différence de coloration de l'épiderme. A notre connaissance, ce travail est le premier qui porte sur la biométrie et sur l'analyse morphométrique du dimorphisme sexuel chez cette espèce. L'échantillon récolté (100 individus) est statistiquement représentatif de la sous-espèce abordée (*S. s. scincus*), dans une région donnée. Il serait intéressant de pouvoir comparer nos résultats à ceux obtenus pour la même espèce dans d'autres zones géographiques au sein de son aire de répartition et n'ayant pas de contacts génétiques. La mise en évidence de sous-espèces géographiques ou de sous-populations reste donc à être appréhendée. Pour une espèce qui peut devenir d'un intérêt économique évident, puisque toutes les analyses montrent que ce lézard est un aliment d'une grande valeur nutritionnelle (la consommation de 100 g de ce lézard couvre plus que la moitié des apports nutritionnel quotidiens conseillés) et permettent de présager son utilisation dans les domaines alimentaire et pharmaceutique (Toumi *et al.*, 2017), il devient fondamental de mieux connaître son anatomie.

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Les auteurs tiennent à remercier chaleureusement Messieurs Ian Nicholson et Marc Bridou (Nantes) pour leur aide à la traduction anglaise du résumé et des mots-clés. Merci également à Catherine Picard (Unité d'anatomie comparée de l'Ecole Nationale Vétérinaire de Nantes – Oniris) pour la mise en forme de la Figure 2.

RÉFÉRENCES

Abo-Eleneen R. E., El-Bakry A. M., Abdeen A. M. 2014. Ultra-structural Study of the Alimentary Tract of Two Reptilian Species the Lizard *Scincus scincus* and the Snake *Natrix tessellata*. *Journal of Cytology & Histology* S4 : DOI : 10.4172/2157-7099.S4-01

Arnold E. N., Leviton A. E. 1977. A revision on the lizard genus *Scincus* (Reptilia : Scincidae). *Bulletin of the British Museum (Natural History - Zool), London* 31(5) : 189-248.

Baumgartner W., Fidler F., Weth A., Habbecke M., Jakob P., Butenweg C., Böhme W. 2008. Investigating the Locomotion of the Sandfish in Desert Sand Using NMR-Imaging. *PLoS ONE* 3 : e3309, DOI : 10.1371/journal.pone.0003309.

Benhaoua D., Khaldi D. 2019. Contribution à l'étude de la variabilité morphologique du lézard *Scincus scincus* (Linnaeus, 1758) dans la région d'El Oued. Master en Sciences biologiques, spécialité Biodiversité et environnement, Université Echahid Hamma Lakhdar - El Oued (Algérie), Faculté des Sciences de la Nature et de la Vie, Département de biologie, http://dspace.univ-eloued.dz/bitstream/123456789/4311/1/574.01.061.pdf, 85 pp.

El-Bakry A. M., Abdeen A. M., Abo-Eleneen R. E. 2012. Anatomical and Morphometrical Study of the Alimentary Canal of the Lizard *Scincus scincus* and the snake *Natrix* tessellata. *Life Science Journal* 9(4) : 1010-1022.

Hetherington T. E. 1989. Use of vibratory cues for detection of

insect prey by the sandswimming lizard *Scincus scincus*. *Animal Behaviour* 37(2): 290-297.

Pianka E. R., Vitt L. J. 2003. Lizards, Windows to the Evolution of Diversity. *University of California Press., USA*, 348 pp.

Russel A. P., Bels V. 2001. Biomechanics and kinematics of limb-based locomotion in lizards: review, synthesis and prospectus. *Comparative biochemistry and physiology. Part A*, 131(1): 89-112.

Salem S. B., Miles D. B., Alm-Eldeen A. A., Kandyel R. M. 2017. Comparative histological characterization of the tongue in two reptiles; *Scincus scincus* (Scincidae) and *Uromastyx ornata* (Agamidae) in relation to diet. *The Egyptian Journal of Experimental Biology (Zoology)* 13(2): 319-327.

Shafiei S., Sehhatisabet M. E., Moradi N. 2015. New record of Sandfish Skink, *Scincus scincus conirostris* Blanford, 1881 (Sauria: Scincidae) from southeastern Iran. *Check List* 11(5): 1774, DOI: 10.15560/11.5.1774.

Sharpe S. S., Ding Y., Goldman D. I. 2013. Environmental interaction influences muscle activation strategy during sand-swimming in the sandfish lizard *Scincus scincus*. *Journal of Experimental Biology* 216: 260-274.

Sindaco R. 1998. Annoted Checklist of the Reptiles of the Mediterranean countries, with keys to Asiatic and African Species. Part 1 - Turtles, Crocodiles, Amphisbaenians and Lizards (pp. 85-190). *Annali del Museo Civico di Storia Naturale « G. Doria », Genova,* 92: 85-190.

Stadler A. T., Vihar B., Günther M., Huemer M., Riedl M., Shamiyeh S., Mayrhofer B., Böhme W., Baumgartner W. 2016. Adaptation to life in aeolian sand: how the sandfish lizard, *Scincus scincus*, prevents sand particles from entering its lungs. *Journal of Experimental Biology* 219: 3597-3604.

Toumi I., Adamou A., Becila S., Rgiloufi R. 2017. Composition et valeur nutritionnelle de la viande et la farine du scinque officinal (*Scincus scincus*) en Algérie. *Livestock Research for Rural Development*, 29(10): 13, http://www.lrrd.org/lrrd29/10/toum29190.html.

Whiting A. S. 2004. Phylogenetic Systematics and Evolution within the Family Scincidae. PhD dissertation. Brigham Young University - Provo, 97 pp., https://scholarsarchive.byu.edu/etd/1133.

Whiting A. S., Bauer A. M., Sites J. W. 2003. Phylogenetic relationships and limb loss in sub-Saharan African scincine lizards (Squamata: Scincidae). *Molecular Phylogenetics and Evolution* 29(3): 582-598.

Wu W., Lutz C., Mersch S., Thelen R., Greiner C., Gomard G., Hölscher H. 2018. Characterization of the microscopic tribological properties of sandfish (*Scincus scincus*) scales by atomic force microscopy. *Beilstein Journal of Nanotechnology* 9: 2618-2627.

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An integrative taxonomic classification and description of two new Cryptorhynchinae from Northwest Africa (Coleoptera: Curculionidae)

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Abstract: Two new species, *Acalles romani* and *Echinodera philippei*, are described from Algeria and Morocco and are distinguished from related species. They are incorporated in the current key to the North African *Acalles* and *Echinodera* species. In addition to morphological characters, first molecular results (DNA barcoding) are presented. The new taxa are included in phylogram of the most closely related species from Northwest Africa, Spain, Italy and the Iberian Peninsula.

Keywords: *Acalles* - *Echinodera* - new species - morphology - molecular analysis - barcoding - integrative taxonomy - distribution map - Morocco - Algeria.

INTRODUCTION

In recent years, research and collecting trips to North African countries have become increasingly difficult for European scientists. It is therefore all the more gratifying that the colleagues Roman Borovec (Czech Republic) and Philippe Ponel (France) recently succeeded in collecting the two new Cryptorhynchinae species herein in Morocco and Algeria. Algeria in particular is still a *terra incognita* for Cryptorhynchine research, particularly in large parts of the Tell Atlas, the wildly rugged Kabylia, the Ouarsensis Mountains and the Sahara Atlas. Similar to what has already happened throughout much of Morocco (Stüben, 2001, 2002, 2003, 2004b), dozens of still undescribed species can be expected to be found here, especially in the genera *Acalles* Schoenherr, 1825, *Kyklioacalles* Stüben, 1999 and *Echinodera* Wollaston, 1863, but also in the tribe of the difficult to detect, subterranean Torneumatini (Stüben *et al.*, 2010; Stüben, 2018).

As already described elsewhere, the range of the *Acalles sierrae* group (Stüben, 2004a), which is widespread on the Iberian Peninsula, continues on the other side of the Strait of Gibraltar into the mountains of Morocco, including the Rif Mountains, the Middle and High Atlas as well as the Anti-Atlas (Schütte & Stüben, 2015: fig. 7). More than a dozen species from this group have become known so far, usually inhabiting a narrowly limited distribution area and often only found on a few mountain peaks (ice age relicts?). So far, the first author has only been able to describe *Acalles testensis* Stüben, 2003 from the Tizi-n-Test and *Acalles asniensis* Stüben, 2003 from the surroundings of Imlil. These were the most eastern species known from the High Atlas, but Roman Borovec has now succeeded in discovering the next species of the *sierrae* group, 150 km northeast of these localities, on Jbel M'Goun (2774 m, Fig. 1). It is expected that, provided safe travel for scientists to such areas is possible, new species will be discovered in each mountain range which is separated from its neighbours by deep, dry valleys. In several ways, the overall 'continental' distribution pattern in many aspects resembles the situation resulting from presumably similar evolutionary process on the Macaronesian islands, where each island lead probably to the evolution of a new sibling species due to the geographic isolation.

A detailed traditional description of the new species, which would only repeatedly record the few, always the same, morphological characters of all *Echinodera* species and the species from the *Acalles* sierrae group, has been omitted this time in favour of more meaningful differential diagnoses. In addition, molecular phylogenies (Fig. 7, 13) are presented for the new and related species and DNA barcoding sequences from all species in the phylogeny trees are deposited in GenBank, the sequences of the new species are being provided within this manuscript (Appendix 1), which will allow a clear (re) identification of the new taxa in the future.

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Fig. 1. Roman Borovec at the 'sunshine selection' of his sifting of the new species *Acalles romani*, named after him, on the Jbel M'Goun of the High Atlas at an altitude of over 2700 m. Numerous other species of the *Acalles sierrae* group can be expected on other such mountain tops of the Middle-, High- and Anti-Atlas (photo by R. Borovec).

MATERIAL AND METHODS

The material of Acalles and Echinodera species on which the morphological and molecular analyses are based was collected, prepared and identified by the first author – except for the two species newly described here, which were provided by P. Ponel and R. Borovec. The morphological reference material is part of the Western Palaearctic Cryptorhynchinae collection of the first author in Senckenberg, Deutsches Entomologisches Institut (SDEI, Germany: Müncheberg). The sequences of the two new species were provided by the laboratories of the SDEI. All the other sequences were provided by the laboratories of the Alexander Koenig Research Museum (ZFMK, Germany: Bonn) in cooperation with the Curculio Institute as part of the Molecular Project for the Identification of Weevils (MWI, Schütte *et al.,* 2013 and Stüben *et al.,* 2015) or previous collaborations (Astrin & Stüben, 2008, 2010; Astrin *et al.,* 2012).

In both facilities the widely used Folmer DNA barcode region (Folmer *et al.*, 1994) of Cytochrome C oxidase subunit I gene (CO1) has been sequenced. The barcodes of the new species were amplified with weevil-adopted LCO1490-JJ and HCO2198-JJ primers (Astrin & Stüben, 2008), obtaining 658 nucleotides per sequence for full length barcode. The sequenced specimens are deposited in the first author's collection and in ZFMK. The extracted DNA samples are stored in ZFMK and SDEI.

Details on the specimens, finding spots and corresponding GenBank accession numbers are provided in type material sections of the new described species and for all other *Acalles* and *Echinodera* species in Astrin & Stüben (2010) and Schütte & Stüben (2015).

The Bayesian analysis of 43 *Acalles* sequences and 36 *Echinodera* sequences was carried out using MrBayes 3.2.7a for Windows (Ronquist & Huelsenbeck, 2003). The nucleotide substitution model HKY+I+G (code = metmt nst = 2 rates = invgamma) was designated, as previously suggested by jModelTest 0.1.1 (Posada, 2008). The Bayesian analysis was run for 20 million generations (samplefreq = 1000). Average standard deviation of last split frequencies for *Acalles*: 0.002323, and for *Echinodera*: 0.003038 (<0.01 suggested). The standard setting of two independent analyses (Nruns = 2) calculated 40,002 trees in 2 files. After absolute burnin of 40 trees per file, 39,922 trees have been retained and a 50%-majority rule consensus tree with posterior probability values was built (Figs 7, 13). Geneious Pro 6.5.8 was used for graphical display of the tree.

TAXONOMY

Acalles romani Stüben spec. nov.

Figs 1-7

Type material: Holotype, 1♂, "MOROCCO, Haut Atlas, M'Goun, Tizi-n-Ait Ahmed, N side, 2774 m, 31°32'57"N 6°16'13"W, 16.V.2017, R. Borovec lgt.", coll. Senckenberg, Deutsches Entomologisches Institut (SDEI Coleoptera #300891). DNA-types (CO1) (= holotype): collector's no.: 3421-PST, GenBank: MW021556. – Paratypes, 3♂, 1♀, data as for holotype, coll. Stüben, Borovec, SDEI.

Description and differential diagnosis: Length: 2.2 - 2.8 mm (without rostrum). The species corresponds in most external characters to the species *Acalles iblanensis* Stüben, 2015, from the Middle Atlas north of Imouzzer-des-Marmoucha on the Jbel Bou Iblane previously described by the first author (in Schütte & Stüben, 2015: see Fig. 4). Unlike this species, however, the long oval and acuminate elytra are not marbled dark and light brown, but are uniformly brown and are 1.3x - 1.4x longer than broad (length-width ratio of the elytra of *A. iblanensis*: 1.2x -1.3x). Similar to the species from the Middle Atlas the clubbed bristles on the sutural stripe and intervals are at most 2.5 to 3 times as long as wide and are separated by two to three times the length of a bristle. The striae are smaller than the intervals, with elongate, closely packed shallow punctures. The laterally strongly rounded pronotum is very similar to *A. iblanensis* (with the exception of the marbled integument), with a slight depression at the sides directly behind the fore-margin. But the most significant differences between the two species are found in both sexes in the shape and length of the red brown rostrum: in males length-width ratio of 3.5 (versus 4.0 in *A. iblanensis*) between insertion of antennae; closely covered with white and beige scales in front of base, finely punctate towards apex; rostrum of females clearly longer; length-width ratio of 4.3 (versus 5.5) between insertion of antennae, more shiny, more finely punctate. However, a definite distinguishing character is the shape of the median lobe of the aedeagus, which in *A. romani* is always laterally undulating. The different inner structures of the sac of aedeagus are also a great help, see Fig. 5. Figure 6 shows the different female genitalia.

Morphological classification of the new species: The 'Key to the species of *Acalles* Schoenherr, 1825' in Stüben (2018: 44), which contains over 40 species, must be supplemented by the following additions:

[1] Aedeagus with sclerotized internal sac (*Acalles* s.str.) / [2'] External elytral intervals without bump-like elevations / [3'] Elytra elongate-oval, at least 1.25x as long as wide / [30'] Male only with a apically split-tibial spine / [31'] Elytral bristle at least 2.5x as long as wide / [32] Marbled elytra more short-oval: length-width ratio 1.2 to 1.3 ..... ***Acalles iblanensis* Stüben, 2015**

[32'] Monochrome brown elytra more elongated: length-width ratio 1.3 to 1.4 ..... ***Acalles romani* spec. nov.**

Fig. 2. Holotype (male) of *Acalles romani* spec. nov. from Morocco (Jbel M'Goun), specimen size = 2.9 mm, scale bar 2 mm.

Fig. 3. Paratype (female) of *Acalles romani* spec. nov. from Morocco (Jbel M'Goun), specimen size = 2.9 mm, scale bar 2 mm.

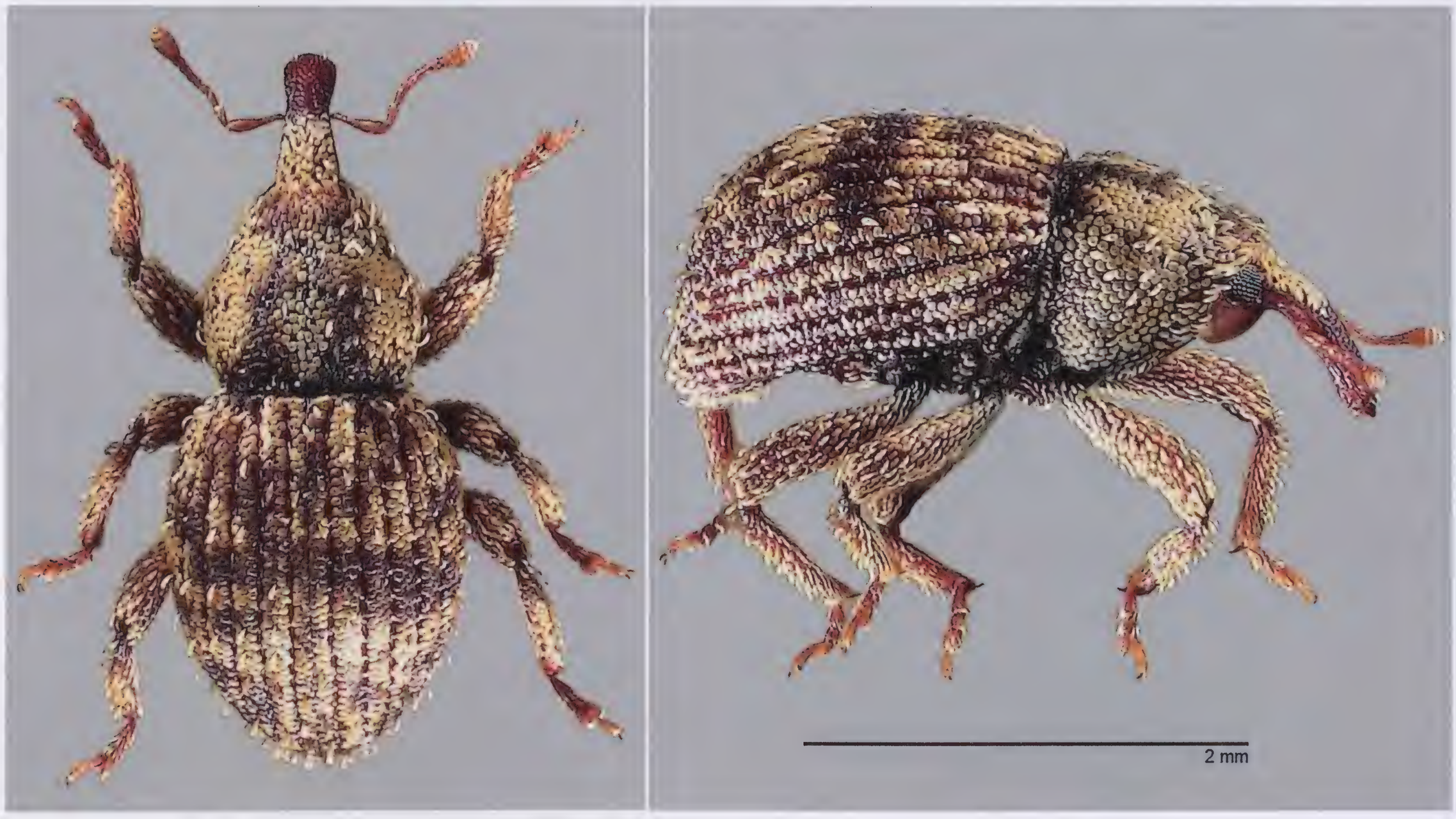


Fig. 4. Holotype of *Acalles iblanensis* Stüben, 2015 from the Middle Atlas of Morocco, specimen size = 2.6 mm, scale bar 2 mm.

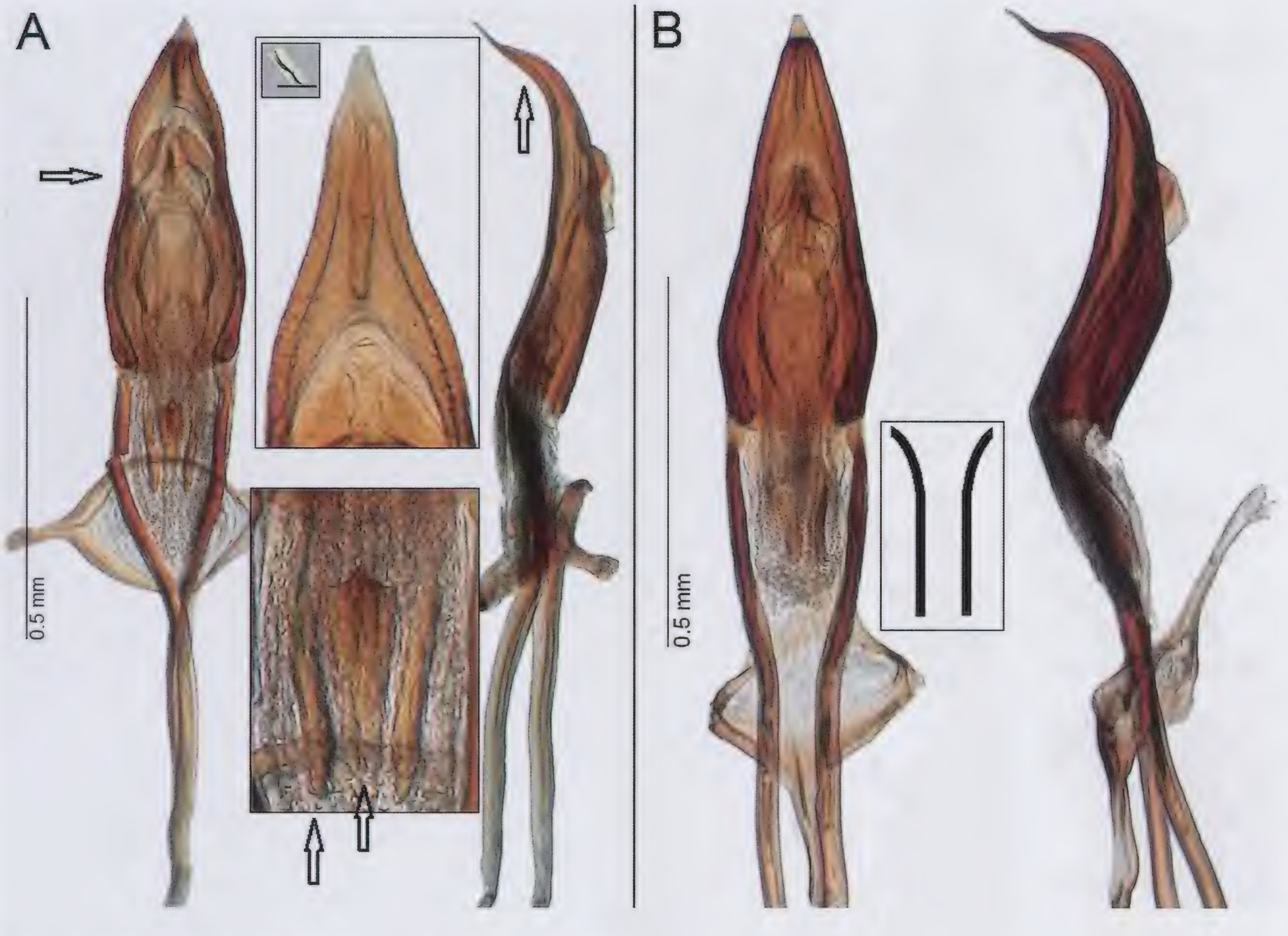


Fig. 5. Aedeagi of (A) *A. romani* spec. nov. and (B) *A. iblanensis*.

The species is thus to be placed in the current key to *Acalles* between *A. iblanensis* from the Middle Atlas and *A. testensis* Stüben, 2003 as well as *A. asniensis* Stüben, 2003 from the High Atlas of Morocco.

Molecular classification of the new species: Methods for obtaining the COI sequence and the process of the Baysian analysis are presented in the section 'Material and methods' (see above). This is not already a more comprehensive or robust phylogenetic classification, which would naturally require additional gene segments, especially nuclear genes (see Astrin *et al.*, 2012; Schütte & Stüben, 2015). Nevertheless, this first molecular classification of the *Acalles sierra* group (see Fig. 7) shows a great concordance with the morphological classification. All these species are highland species from the mountain peaks of the Iberian Peninsula and North-West Africa, almost always above 2000 m a.s.l. The adelphotaxa of the new species are *Acalles testensis* and *A. asnienis* from the western part of the High Atlas, and all together form the sister clade of *A. iblanensis* from the Middle Atlas of Morocco. The uncorrected p-distances in percent of mtCOI subgene between *Acalles romani* sp.n. and *Acalles testensis* / *A. asiensis* are 9% / 7.2%, and the distance between the new species and *A. iblanensis* is 10.2%. Even from this point of view and in comparison with the interspecific molecular distances of the more than 40 species of the genus *Acalles* (cf. Schütte & Stüben, 2015), everything argues for an independent species in case of *A. romani*.

Dedication: I dedicate the species to my esteemed colleague Roman Borovec from the Czech Republic (Kamýcká), who generously made the small series of the new species available to me.

Ecology: *A. romani* was sifted together with *Cathormiocerus jeanneli* Ruter, 1941 (Entiminae) by Roman Borovec under a cushion-like Fabaceae (perhaps *Astragalus*) at an altitude of over 2700 m a.s.l. in the High Atlas of Morocco.

Distribution: This species is so far known only from the type locality (Jbel M'Goun) in the High Atlas of Morocco.

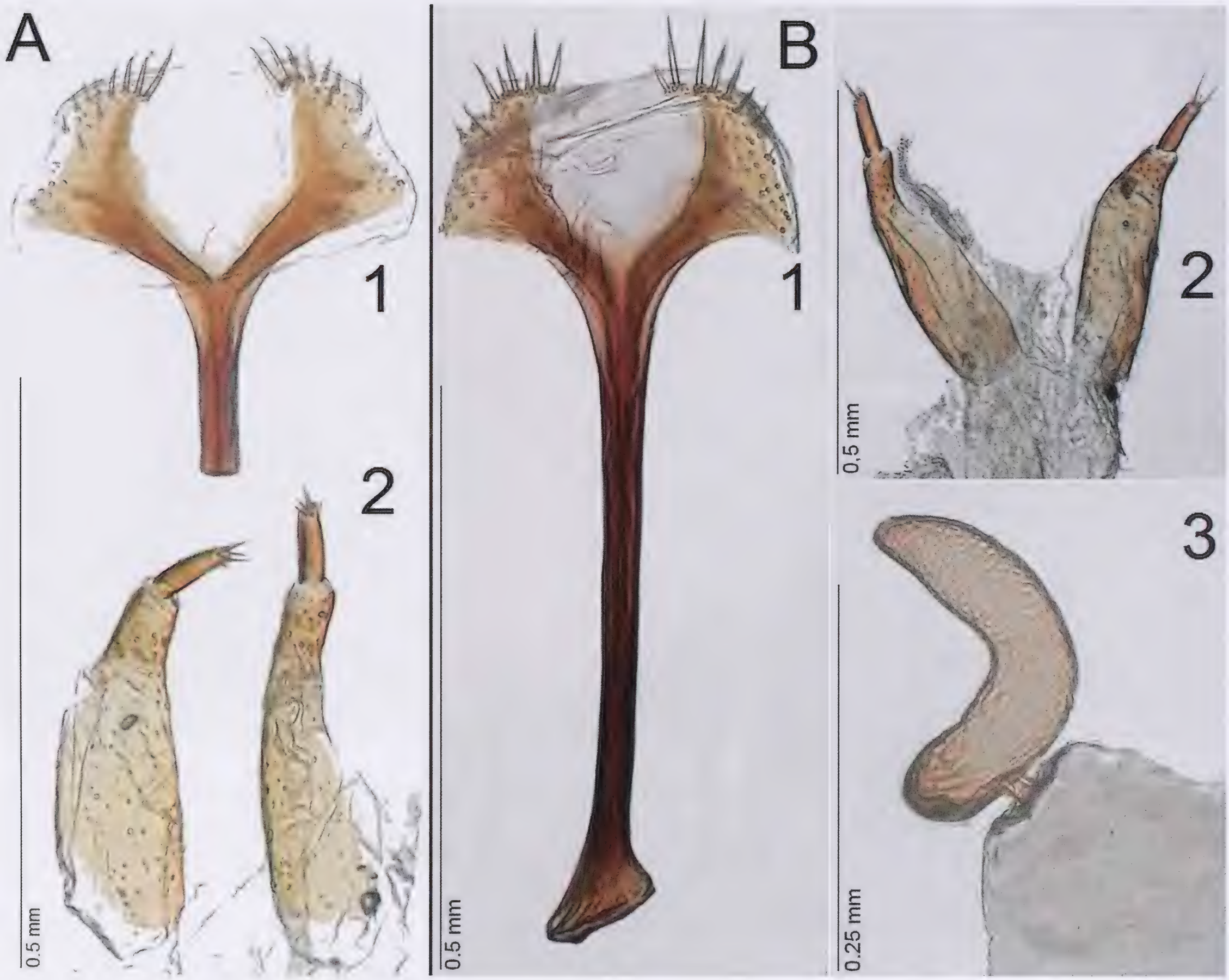


Fig. 6. Female genitalia (1 Spiculum ventrale, 2 Ovipositor, 3 Spermatheca) of (A) *A. romani* spec. nov. (paratype) and (B) *A. iblanensis* (paratype).

Echinodera philippei Stüben spec. nov.

Figs 8-11, 13, 14

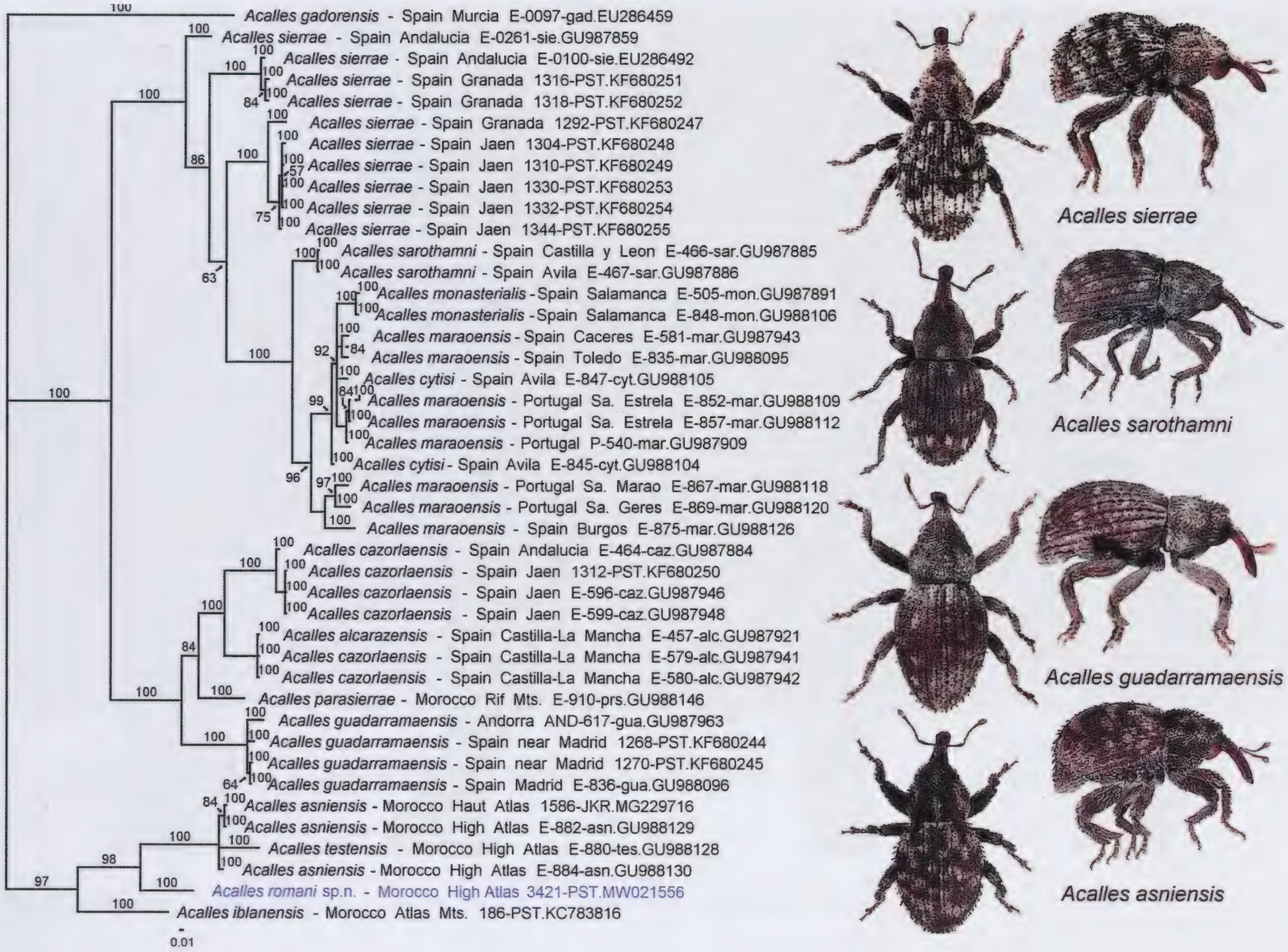
Type material: Holotype, 1♂, "ALGERIE, Route N22, 6 km de Tlemcen vers Terny Ben Hadiel, litière *Quercus ilex*, 15.1.2018, P. Ponel // N34°46'39" W01°20'46". – Paratypes, 2♂, 3♀, data as for holotype, coll. Stüben, Ponel, SDEI. DNA type (CO1) (= further paratype, data as for holotype): collector's no.: 3190-PST, GenBank: MW021555.

Description

Length: 2.70 - 3.75 mm (without rostrum).

Pronotum: 1.15x - 1.25x as wide as long; widest point behind the middle, in front of the base laterally strongly rounded, towards the fore-margin straight or with a slight depression; disc of pronotum (lateral view) flat, in dorsal view with a large and dense punctures. Every puncture with a short bristle; pronotum mostly covered with dark brown scales, in the center in front of the base with some bright scales as well as bright and irregularly bordered spots on the sides.

Elytra: Short-oval, males 1.04x -1.08x as long as wide (females sometimes more elongated, long-oval); widest at the end of the first third of the elytra, laterally equally rounded; in lateral view, contour-line of the elytra, which slightly surpasses the line of the pronotum, begins with a flat circular line and it drops down vertically towards the apex. The base of elytra is straight. The integument comprises more or less uniformly dark and light brown, irregularly bordered spots of scales. A beige, "M"-shaped fascia, typical for most species of *Echinodera*, is only adumbrated behind the middle on the first three intervals, but can also be completely missing. The striae are clearly slenderer than the slightly arched intervals; these are covered with a single row of bristles, which are raised significantly above the surface (further raised on the elytral slope); the flattened bristles are conically widened (clubbed) towards the tip, 1.5x - 2x as long as wide and


Acalles gadorensis - Spain Murcia E-0097-gad.EU286459
Acalles sierrae - Spain Andalucia E-0261-sie.GU987859
Acalles sierrae - Spain Andalucia E-0100-sie.EU286492
Acalles sierrae - Spain Granada 1316-PST.KF680251
Acalles sierrae - Spain Granada 1318-PST.KF680252
Acalles sierrae - Spain Granada 1292-PST.KF680247
Acalles sierrae - Spain Jaen 1304-PST.KF680248
Acalles sierrae - Spain Jaen 1310-PST.KF680249
Acalles sierrae - Spain Jaen 1330-PST.KF680253
Acalles sierrae - Spain Jaen 1332-PST.KF680254
Acalles sierrae - Spain Jaen 1344-PST.KF680255
Acalles sarothamni - Spain Castilla y Leon E-466-sar.GU987885
Acalles sarothamni - Spain Avila E-467-sar.GU987886
Acalles monasterialis - Spain Salamanca E-505-mon.GU987891
Acalles monasterialis - Spain Salamanca E-848-mon.GU988106
Acalles maraoensis - Spain Caceres E-581-mar.GU987943
Acalles maraoensis - Spain Toledo E-835-mar.GU988095
Acalles cytisi - Spain Avila E-847-cyt.GU988105
Acalles maraoensis - Portugal Sa. Estrela E-852-mar.GU988109
Acalles maraoensis - Portugal Sa. Estrela E-857-mar.GU988112
Acalles maraoensis - Portugal P-540-mar.GU987909
Acalles cytisi - Spain Avila E-845-cyt.GU988104
Acalles maraoensis - Portugal Sa. Marao E-867-mar.GU988118
Acalles maraoensis - Portugal Sa. Geres E-869-mar.GU988120
Acalles maraoensis - Spain Burgos E-875-mar.GU988126
Acalles cazorlaensis - Spain Andalucia E-464-caz.GU987884
Acalles cazorlaensis - Spain Jaen 1312-PST.KF680250
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Acalles cazorlaensis - Spain Jaen E-599-caz.GU987948
Acalles alcarazensis - Spain Castilla-La Mancha E-457-alc.GU987921
Acalles cazorlaensis - Spain Castilla-La Mancha E-579-alc.GU987941
Acalles cazorlaensis - Spain Castilla-La Mancha E-580-alc.GU987942
Acalles parasierrae - Morocco Rif Mts. E-910-prs.GU988146
Acalles guadarramaensis - Andorra AND-617-gua.GU987963
Acalles guadarramaensis - Spain near Madrid 1268-PST.KF680244
Acalles guadarramaensis - Spain near Madrid 1270-PST.KF680245
Acalles guadarramaensis - Spain Madrid E-836-gua.GU988096
Acalles asniensis - Morocco Haut Atlas 1586-JKR.MG229716
Acalles asniensis - Morocco High Atlas E-882-asn.GU988129
Acalles testensis - Morocco High Atlas E-880-tes.GU988128
Acalles asniensis - Morocco High Atlas E-884-asn.GU988130
Acalles romani sp.n. - Morocco High Atlas 3421-PST.MW021556
Acalles iblanensis - Morocco Atlas Mts. 186-PST.KC783816
0.01
Acalles sierrae
Acalles sarothamni
Acalles guadarramaensis
Acalles asniensis

Fig.7. Bayesian 50% majority rule consensus tree using Cytochrome c oxidase subunit I gene (CO1, 658 bp) to classify the new species *A. romani* (marked in blue) among the related species of the *Acalles sierrae* group from Northwest Africa and Iberian Peninsula. Order: Genus / species / location / collector's no. / GenBank acc. no. (CO1).

separated by 0.5 - 1.0x of a bristle-length; 30-35 bristles are placed in a row on the first intervals, they stand more densely packed on the slope of the elytra.

Head & Rostrum: Eyes long-oval, placed at the sides of the head; in dorsal view only visible as narrow stripes and not reaching up beyond the upper margin of the antennal groove; the dark brown rostrum of male deeply and closely punctate and 3.2x as long as wide (breadth of rostrum measured between insertion of antennae); rostrum of female also with deep punctures, slenderer and at least 4x as long as wide.

Legs: Short; front femora reach the fore-margin of the eyes, hind femora reach the fore-margin of the last abdominal segment. Spine at the end of the hind tibia of males curved inwards almost at a right-angle.

Venter: 1st abdominal sternite clearly longer than the three following sternites together.

Aedeagus: Median lobe ventrally not strongly curved, with an S-shaped, long and tapering, transparent and bottleneck-shaped tip (Fig. 10A).

Female genitalia: See Fig. 11A.

Morphological classification of the new species: The 'Key to *Echinodera* from Northern Africa' in Stüben (2018: 318) with more than 80 species must be supplemented by the following additions:

[1'] Spine at the end of the hind tibia of males curved inwards almost at a right-angle (Fig. 11B1) / [7'] Elytral bristles not at least 4x - 6x longer than wide, much shorter (1.5x - 2x as long as wide) / [8'] Elytral striae clearly slenderer than the intervals (not with deep and wide punctures) / [11'] Elytra of males short oval: < 1.08x as long as wide / [16'] Elytral intervals – at least on the elytral slope – with nearly vertically erect bristles (not predominantly recumbent) / [21'] Only the intervals of the elytral slope with vertically erect and shorter bristles (not the entire surface of the elytra with 'hedgehog-like' and longer bristles).

The new species, originating from the northwest of Algeria, must be placed at the very end of the current key to the North African *Echinodera* (Stüben, 2018) and is morphologically similar to *E. hoceimaensis* and *E. ceutaensis* from the North of Morocco, but especially

Fig 8. Holotype (male) of *Echinodera philippei* spec. nov. from Algeria (near Tlemcen), specimen size = 3 mm, scale bar 2 mm.

Fig. 9. Paratype (female) of *Echinodera philippei* spec. nov. from Algeria (near Tlemcen), specimen size = 4.2 mm, scale bar 2 mm.

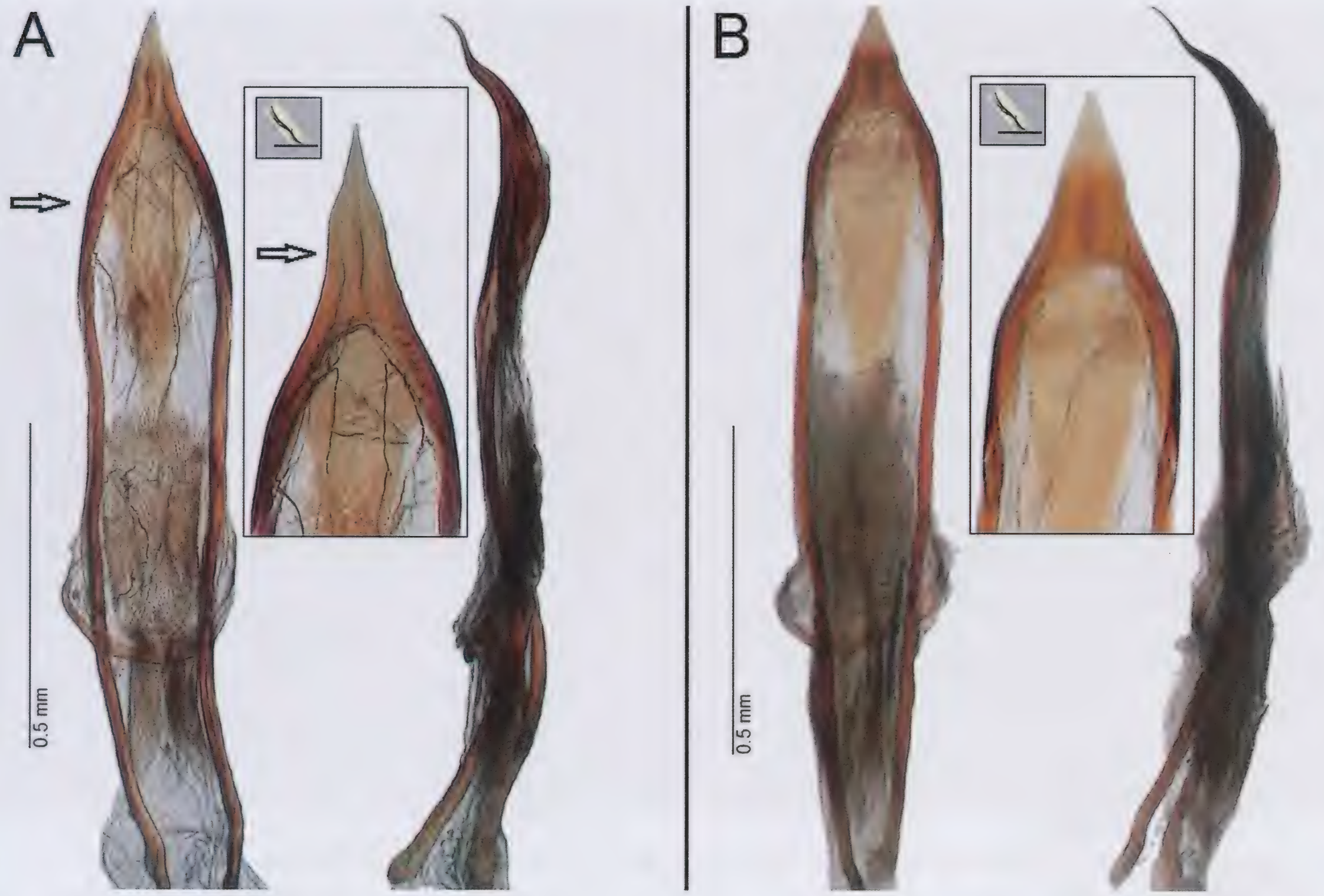


Fig. 10. Aedeagi of (A) *E. philippei* spec. nov. and (B) *E. capbonensis capbonensis* Stüben, 2004b.

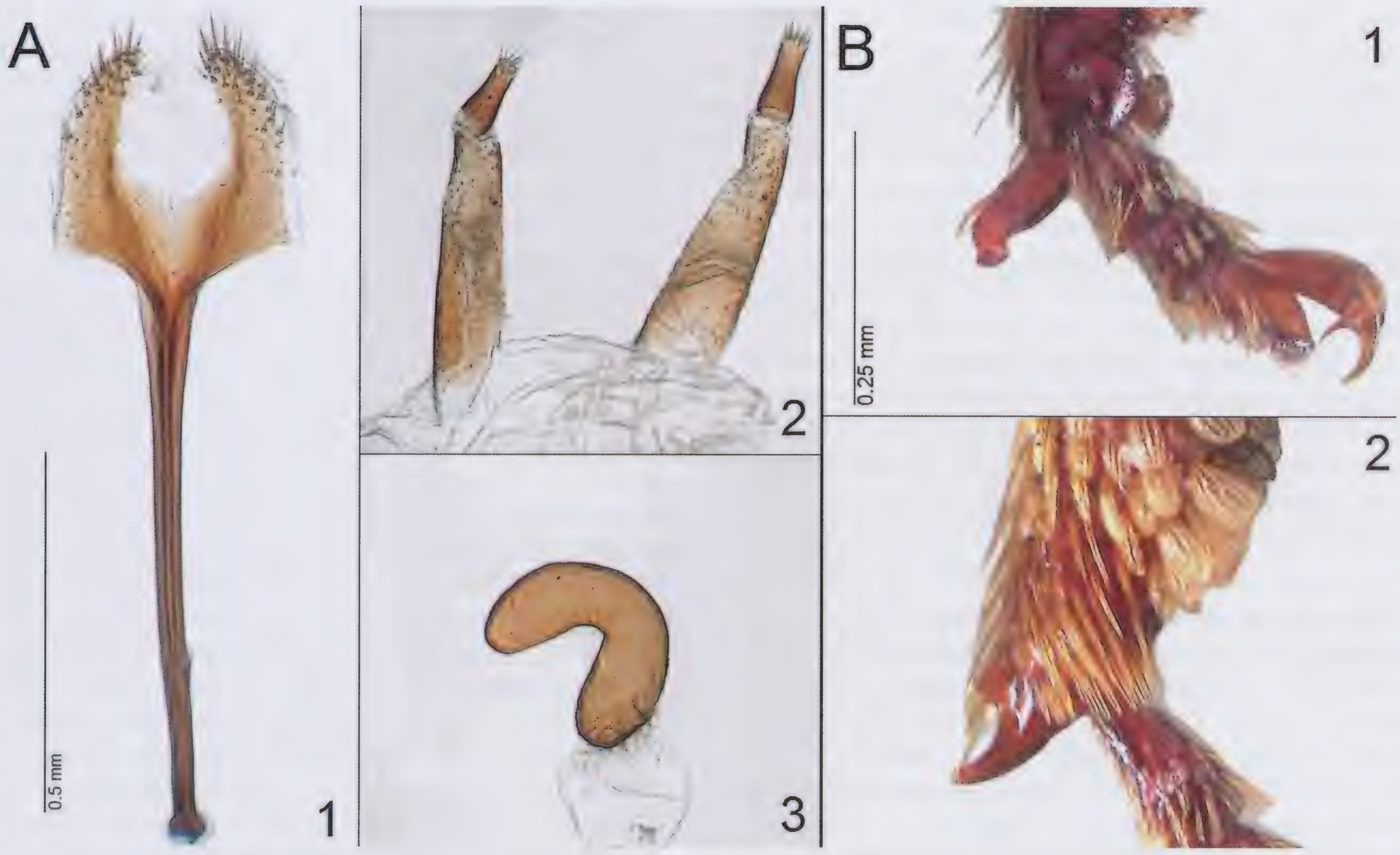


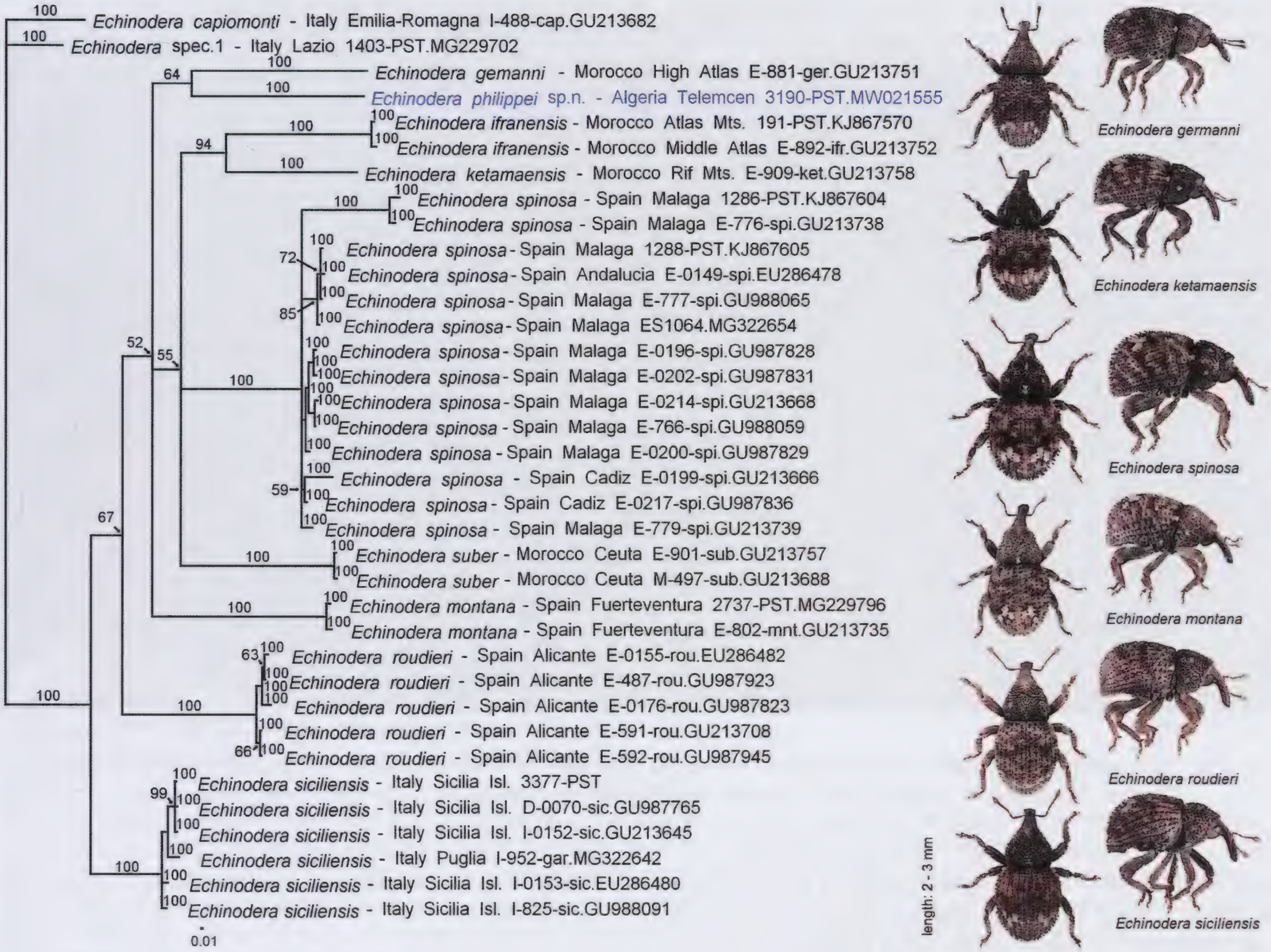
Fig. 11. (A) Female genitalia of *E. philippei* spec. nov. (1. Spiculum ventrale, 2. Ovipositor, 3. Spermatheca). (B) Spine at the end of the hind tibia of males of 1. *E. philippei* spec. nov. and 2. *E. germanni.*

Fig. 12. Holotype (male) of *Echinodera capbonensis diotti* Stüben, 2010 from the island Pantelleria (Italy).

to *Echinodera capbonensis capbonensis* Stüben, 2004 from Tunisia and the further subspecies *Echinodera capbonensis diotti* Stüben, 2010 from the Italian island Pantelleria (Fig. 12). However, *E. philippei* differs from both (sub)species by the narrower and more finely punctate striae and clearly wider bristles on the elytra; in addition, the aedeagus becomes narrower towards the apex and is more tapered like a bottle neck (Fig. 10A). The morphological separation from the poorly-known species *Echinodera fusca* (Chevrolat, 1861) and *Echinodera costata* (Chevrolat, 1861), both described from Algeria, could be problematic. However, the lectotype of *E. fusca* (a female), which I already designated in 2001, has a much more strongly and deeply punctured pronotum and clearly narrower elytral bristles, and the species *E. costata* has much wider and more deeply punctured striae on the elytra (see illustrations of both species in my internet catalogue in: Stüben, 2020). But with only a limited number of taxonomically informative characters available in the very similar ('cryptic') *Echinodera* species (see also the illustrations of some *Echinodera* species in Fig. 13), morphological classification can only serve for the (re)identification of species; e.g. in the form of a species key. Therefore, a classification showing the relationships of species is here only possible using molecular methods, which provides many more 'characters and signals' (see also Astrin & Stüben, 2010).

Molecular classification of the new species: Most of the 82 *Echinodera* species are distributed around the Mediterranean, only a few are found in the Caucasus region, and those of the subgenus *Echinodera* s.str. occur in the Canary Islands and the Salvage Islands. The molecular phylogenetic analysis of all these species using the genes CO1, 16S and 28S can be found in Astrin & Stüben (2010), Astrin *et al.* (2012), and at last almost completely in Stüben, 2018 (pp. 9, 254).

The Bayesian 50% majority rule consensus tree of the mtCO1 gene presented here is based on 36 samples of 10 (of the total of 82) closely related *Echinodera* species from Northwest Africa, the Canary Islands (Fuerteventura), Italy (mainly from Sicily) and the Iberian Peninsula (Fig. 13). In this tree, *Echinodera philippei* sp.n. appears – initially surprising from a morphological point of view – as sister taxon of *Echinodera germanni*, a species described by the first author from the High Atlas of Morocco (Stüben, 2003). However, this species from the Tizi-n-Test, a mountain pass located about 800 km westwards, has somewhat elongated elytra in both sexes (at least 1.23x as long as wide), but is similar to the new species in the length and width of the elytral bristles, their dense placement and in the cloudy coloration of the elytra. But there is a difference that cannot be overlooked: The male of *Echinodera germanni* Stüben, 2003, has a straight spine at the end of the hind tibia and not – like the new species – an inwardly curved, almost right-


Echinodera capiomonti - Italy Emilia-Romagna I-488-cap.GU213682
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Echinodera gemanni - Morocco High Atlas E-881-ger.GU213751
Echinodera philippei sp.n. - Algeria Telemcen 3190-PST.MW021555
Echinodera ifranensis - Morocco Atlas Mts. 191-PST.KJ867570
Echinodera ifranensis - Morocco Middle Atlas E-892-ifr.GU213752
Echinodera ketamaensis - Morocco Rif Mts. E-909-ket.GU213758
Echinodera spinosa - Spain Malaga 1286-PST.KJ867604
Echinodera spinosa - Spain Malaga E-776-spi.GU213738
Echinodera spinosa - Spain Malaga 1288-PST.KJ867605
Echinodera spinosa - Spain Andalucia E-0149-spi.EU286478
Echinodera spinosa - Spain Malaga E-777-spi.GU988065
Echinodera spinosa - Spain Malaga ES1064.MG322654
Echinodera spinosa - Spain Malaga E-0196-spi.GU987828
Echinodera spinosa - Spain Malaga E-0202-spi.GU987831
Echinodera spinosa - Spain Malaga E-0214-spi.GU213668
Echinodera spinosa - Spain Malaga E-766-spi.GU988059
Echinodera spinosa - Spain Malaga E-0200-spi.GU987829
Echinodera spinosa - Spain Cadiz E-0199-spi.GU213666
Echinodera spinosa - Spain Cadiz E-0217-spi.GU987836
Echinodera spinosa - Spain Malaga E-779-spi.GU213739
Echinodera suber - Morocco Ceuta E-901-sub.GU213757
Echinodera suber - Morocco Ceuta M-497-sub.GU213688
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Echinodera roudieri - Spain Alicante E-487-rou.GU987923
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Echinodera roudieri - Spain Alicante E-592-rou.GU987945
Echinodera siciliensis - Italy Sicilia Isl. 3377-PST
Echinodera siciliensis - Italy Sicilia Isl. D-0070-sic.GU987765
Echinodera siciliensis - Italy Sicilia Isl. I-0152-sic.GU213645
Echinodera siciliensis - Italy Puglia I-952-gar.MG322642
Echinodera siciliensis - Italy Sicilia Isl. I-0153-sic.EU286480
Echinodera siciliensis - Italy Sicilia Isl. I-825-sic.GU988091
0.01
Echinodera germanni
Echinodera ketamaensis
Echinodera spinosa
Echinodera montana
Echinodera roudieri
Echinodera siciliensis
length: 2 - 3 mm

Fig. 13. Bayesian 50% majority rule consensus tree using Cytochrome c oxidase subunit I gene (CO1, 658 bp) to classify the new species *E. philippei* (marked in blue) among the related species of *Echinodera* from Northwest Africa, the Canary Islands (Fuerteventura), Italy and the Iberian Peninsula. Order: Genus / species / location / collector's no. / GenBank acc. no. (CO1).

angled hook (Fig. 11B2). If this molecular placement of the new species as a sister taxon of *E. germanni* is accurate, it shows once again that the former division into the subgenera (*Echinodera* s.str. with a straight spine and *Dieckmania* with an inwardly curved spine) is phylogenetically not tenable, but still very useful for a morphological (re)identification of *Echinodera* species (e.g. in a key, see above or Astrin & Stüben, 2010).
The uncorrected p-distance of the mtCO1 gene between the two sister species from Morocco and Algeria is with 16.7% exceptionally high for *Echinodera* species! This suggests that – with an average distribution radius of *Echinodera* species of about 100 km (cf. Stüben, 2018) – there are probably still many related species to be discovered between these distant sites (assuming safe travel for scientists to such areas is possible).

Dedication: I dedicate the species to my esteemed colleague and long-time member of the Curculio Institute Philippe Ponel from France (Pourcieux), who brought the small series of the new species from Algeria.

Ecology: *Echinodera philippei* was sieved from the litter under *Quercus ilex* by Philippe Ponel at an altitude of over 1100 m a.s.l. near Tlemcen in the north-west of Algeria (Fig. 14). The cold and humid relic forest consists of a mix of *Q. ilex* and Q. *faginea* ssp. *tlemcenensis* (A. DC.) Greuter & Burdet there with a very thick layer of dead leaves (in lit. Ponel).

Distribution: This species is so far known only from the type locality near Tlemcen from the north-west of Algeria near the border with Morocco.

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We are grateful to Eva Kleibusch from Senckenberg, Deutsches Entomologisches Institut (SDEI, Müncheberg) for the preparation of the molecular sequences of the

Fig. 14. Type locality near Tlemcen in the north-west of Algeria of the new species *Echinodera philippei*, collected by sieving under *Quercus ilex* (photo by Philippe Ponel / Curculio Institute, bottom right).

new species. Of course, our special thanks go to Roman Borovec (Czech Rep.) and Philippe Ponel (France) for providing the specimen of the new species. We thank Andrew Liston (SDEI) for revising the English text.

REFERENCES

Astrin J.J., Stüben P.E. 2008. Phylogeny in cryptic weevils: molecules, morphology and new genera of Western Palaearctic Cryptorhynchinae (Coleoptera: Curculionidae). *Invertebrate Systematics* 22(5): 503-522.

Astrin J.J., Stüben P.E. 2010. Molecular phylogeny of *Echinodera* and *Ruteria* (Coleoptera: Curculionidae: Cryptorhynchinae) and the parallel speciation of Canary Island weevils along replicate environmental gradients. *Invertebrate Systematics* 24: 434-455.

Astrin J.J., Stüben P.E., Misof B., Wägele J.W., Gimnich F., Raupach M.J, Ahrens D. 2012. Exploring diversity in cryptorhynchine weevils (Coleoptera) using distance-, character- and tree-based species delineation. *Molecular Phylogenetics and Evolution* 63: 1-14.

Chevrolat L.A.A. 1861. Description de coléoptères nouveaux d'Algérie. *Revue et Magasin de Zoologie Pure et Appliquée* (2) 8: 205-209.

Folmer O., Black M., Howh W., Lutz R., Vrijenhoek R. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrate. *Molecular Marine Biology and Biotechnology*, 3(5): 294-299.

Posada D. 2008. jModelTest: phylogenetic model averaging. *Molecular Biology and Evolution* 25(7): 1253-1256.

Ronquist F. & Huelsenbeck J.P. 2003. MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics*, 19(12): 1572-1574.

Ruter G. 1941. Récoltes de R. Paulian et A. Villiers dans le Haut Atlas marocain, 1938 (XIV[e] note) (Coléoptères curculionides). *Revue Française d'Entomologie* 8: 54-76, pl. 1.

Schoenherr C.J. 1825. Continuatio tabulae synopticae familiae curculionidum. *Isis von Oken* 1825 (1)(5): cols. 581-588.

Schütte A., Stüben P.E. 2015. Molecular systematics and morphological identification of the cryptic species of the genus *Acalles* Schoenherr, 1825, with descriptions of new species. *Zootaxa* 3915 (1): 1-51.

Schütte A., Stüben P.E., Sprick P. 2013. The Molecular Weevil Identification Project (Coleoptera: Curculionoidea), Part I. A contribution to an Integrative Taxonomy and Phylogenetic Systematics. *SNUDEBILLER: Studies on taxonomy, biology and ecology of Curculionoidea* 14(211): 1-77.

Stüben P.E. 1999. Taxonomie und Phylogenie der westpaläarktischen Arten der Gattung *Kyklioacalles* g. n. (Coleoptera, Curculionidae: Cryptorhynchinae). *Stuttgarter Beiträge zur Naturkunde,* Ser. A (Biol.) 584: 1-38.

Stüben P.E. 2001. Beschreibung neuer westpaläarktischer *Echinodera*-Arten aus Marokko. Mit einem neuen Schlüssel der Arten des Genus *Echinodera*. (Curculionidae: Cryptorhynchinae). *SNUDEBILLER, Studies on taxonomy, biology and ecology of Curculionoidea* 2(24): 163-179.

Stüben P.E. 2002. Beschreibung neuer Cryptorhynchinae aus Marokko. *SNUDEBILLER, Studies on taxonomy, biology and ecology of Curculionoidea* 3(30): 196-225.

Stüben P.E. 2003. Beschreibung neuer Cryptorhynchinae aus Spanien, Italien und Marokko - mit einem neuen *Onyxa-*

calles- und *Echinodera*-Schlüssel. *SNUDEBILLER, Studies on taxonomy, biology and ecology of Curculionoidea* 4(41): 186-224.

Stüben P.E. 2004a. Beschreibung neuer spanischer Arten aus der *Acalles sierrae*-Gruppe (Coleoptera: Curculionidae: Cryptorhynchinae). *SNUDEBILLER, Studies on taxonomy, biology and ecology of Curculionoidea* 5(55): 86-99.

Stüben P.E. 2004b. Beschreibung neuer tunesischer *Echinodera*-Arten aus der Untergattung *Dieckmannia* (Coleoptera: Curculionidae: Cryptorhynchinae). *SNUDEBILLER, Studies on taxonomy, biology and ecology of Curculionoidea* 5(56): 100-115.

Stüben P.E. 2018. The Cryptorhynchinae of the Western Palearctic. – Die Cryptorhynchinae der Westpaläarktis. (Coleoptera: Curculionidae). *Curculio Institute, Mönchengladbach,* 518 pp.

Stüben P.E. 2020. The Macaronesian Islands - an Encyclopedia of Curculionoidea (Coleoptera). *Le Charançon* (Internet journal of the CURCULIO Institute): Available at http://www.curci.de [initiated in April 2016.].

Stüben P.E., Behne L., Grebennikov V.V. 2010. Rüsselkäfer-Gesiebe-Exkursion des CURCULIO-Instituts im Frühjahr 2009 nach Marokko - unter besonderer Berücksichtigung der Cryptorhynchinae-Fauna. (Coleoptera: Curculionoidea). *SNUDEBILLER, Studies on taxonomy, biology and ecology of Curculionoidea* 11(155): 54-79.

Stüben P.E., Schütte A., Bayer Ch, Astrin J.J. 2015. The Molecular Weevil Identification Project (Coleoptera: Curculionoidea), Part II. Towards an Integrative Taxonomy. *SNUDEBILLER: Studies on taxonomy, biology and ecology of Curculionoidea* 16(237): 1-294.

Wollaston T.V. 1863. Diagnostic notices of new Canarian Coleoptera. *The Annals and Magazine of Natural History* (3) 11 (63): 214-221.

Appendix 1

COI sequences determined for this study

>*Acalles_romani*_spec._nov._3421-PST_GenBank_MW021556
AACTTTATATTTTATCTTTGGGGCATGATCAGGAATATTAGGAACCTCATTAAGTATACTAATCCGAACTGAACTTAGTA-
ACCCAGGAACAATAATTGGAAATGACCAAATTTATAATAGAATTGTTACTGCTCATGCTTTTATCATAATCTTTTTTATAGT-
TATGCCAATCATAATTGGAGGATTCGGAAACTGACTAGTTCCACTAATACTAGGAGCCCCAGATATAGCCTTTC-
CCCGATTAAACAATATAAGATTTTGGTTACTCCCCCCATCTTTAACCCTACTATTAATAAGTAGAATTATCGACAAAG-
GAGCTGGGACTGGATGAACAGTCTATCCCCCACTATCAGCTAATATTGCACATGAGGGAATCTCTGTTGATTTAGC-
CATTTTTAGCCTCCACATAGCAGGAATCTCATCAATTTTAGGAGCTATCAATTTTGTATCTACAATAGCCAATATACGG-
CCTGCAGGAATAAATCTAGATAAAATACCCCTATTTTCTTGAGCTGTAAAAATTACAGCTATTCTACTACTCTTATCTC-
TACCAGTCTTAGCTGGAGCTATTACTATACTCTTAACAGATCGTAATATTAATACATCATTTTTTGATCCTGCTGGAGGAG-
GAGATCCTATCCTTTACCAACACCTATTT

>*Echinodera_philippei*_spec._nov._ 3190-PST_GenBank_MW021555
AACCCTTTACTTTATCTTCGGATCATGATCCGGAATAGTGGGAACATCTTTAAGTTTACTAATTCGTGTAGAACTAG-
GAAACCCAGGAACCCTAATTGGAAATGATCAGATTTATAACACAATCGTAACGGCCCATGCCTTTATCATA-
ATTTTTTTTATAGTTATACCCATCATAATTGGAGGCTTCGGTAATTGATTAGTCCCTTTAATGCTAGGCGCCCCTGA-
TATAGCCTTCCCCCGACTAAATAATATAAGATTCTGATTGCTACCCCCATCCTTAACTCTTCTCCTAATAAGAAGAATTATT-
GATAAAGGAGCTGGGACCGGTTGAACAGTATACCCCCCTTTATCCTCTAATATTGCCCATGAGGGAGCCTCAATTGACT-
TAGCCATCTTCAGGCTCCACATAGCTGGAATCTCTTCGATTCTCGGAGCTATAAATTTTATCTCAACAGTAATTAATATAC-
GTCCAACAGGTATAAAACTAGATCGAATACCTTTATTCGTTTGAGCCGTAAAAATTACAGCTATTCTTCTCCTCCTATC-
CCTCCCTGTCCTAGCAGGGGCTATTACCATACTCTTGACCGACCGAAACATTAATACGTCATTTTTCGACCCCGCTGGAG-
GAGGAGATCCCATCCTTTATCAACACCTTTTC

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New data on linyphiid spiders of Nepal (Arachnida: Araneae), with the description of a new genus and two species

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Abstract: A new genus, *Himalafurca* gen. nov., with two new species, *Himalafurca martensi* sp. nov., the type species, and *H. schawalleri* sp. nov., are described from the Nepal Himalayas. The genus resembles *Ketambea* Millidge & Russell-Smith, 1992 and some other genera of unclear subfamily affiliation, but strongly differs by a few important structural features in the palp. All records of *Collinsia japonica* (Oi, 1964) from Nepal actually refer to *Halorates crassipalpis* (Caporiacco, 1935) comb. nov., here transferred from *Collinsia*. New localities for 21 species known from Nepal are given and six additional species are reported for the fauna of Nepal for the first time: *Agyneta pakistanica* Tanasevitch, 2011, *Bathyphantes paracymbialis* Tanasevitch, 2014a, *Gnathonarium gibberum* Oi, 1960, *Nematogmus dentimanus* Simon, 1886, *Tiso aestivus* (L. Koch, 1872) and *T. indianus* Tanasevitch, 2011. All mentioned species, except the last one, are also new to the fauna of the Himalayas. Taking into account the new data, the spider fauna of Nepal is currently known to include at least 107 linyphiid species, 90% of which presently can be considered as Himalayan endemics.

Keywords: Taxonomy - faunistics - Himalayas - mountain fauna.

INTRODUCTION

The study of linyphiid spiders of Nepal began with publications of Wunderlich (1973, 1974, 1979, 1983) and later continued with papers by Georgescu (1977), Tanasevitch (1987, 1998a, b) and Tanasevitch & Saaristo (2006). After several years of interruption, the study of Nepalese linyphiids was resumed by numerous contributions by Tanasevitch (2018, 2019a, b, c, 2020a, 2021). The basis for the majority of these publication is the spider material collected during numerous expeditions to Nepal organized by Prof. Jochen Martens, kept at the Senckenberg Museum, Frankfurt am Main, Germany (SMF). A quite rich material from Nepal was also found in the spider collection of the Muséum d'histoire naturelle de Genève, Switzerland (MHNG). Specimens from both of these museums were examined for this paper.

At present, 99 linyphiid species are recorded for the fauna of Nepal, 87 of which are known only from this country and from adjacent territories in the Himalayas. This paper describes a new genus of linyphiid spiders which currently includes two new species. It also provides new records of linyphiids for the Nepalese fauna.

MATERIAL AND METHODS

This paper is based on spider material kept in the MHNG and the SMF. In addition, some type specimens were loaned from the Museo civico di Storia naturale, Milano, Italy (MCSNM) and from the National Science Museum, Tokyo, Japan (NSMT). Sample numbers are given in square brackets. Specimens preserved in 70% ethanol were studied using a MBS-9 stereomicroscope. A Levenhuk C-800 digital camera was used for taking photos. The chaetotaxy is given in a formula, e.g., Ti I: 2-1-1-2(1), which means that tibia I has two dorsal, one prolateral, one retrolateral, and two or one ventral spines (the apical spines are disregarded). The sequence of leg segment measurements is as follows: femur + patella + tibia + metatarsus + tarsus. All measurements are given in mm. Scale lines in the figures correspond to 0.1 mm unless indicated otherwise. Figure numbers are given above the corresponding scale lines, the length they represent is given below them. The terminology of copulatory organs mainly follows that of Merrett (1963) and that of authors mentioned in the abbreviations below.

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Abbreviations

C	convector *sensu* Tanasevitch (1998a)
CM	convector membrane
D	duct (spermophor)
E	embolus
Fe	femur
Mt	metatarsus
TeA	tegular apophysis *sensu* Millidge (1995)
TeP	tegular prominence *sensu* Blest (1979)
Ti	tibia
TmI	position of trichobothrium on metatarsus I

TAXONOMY

Himalafurca gen. nov.

Type species: *Himalafurca martensi* sp. nov.

Etymology: The generic name is a combination of two words: part of the name "Himalayas", the "terra typica", and the Latin noun "furca", referring to the fork-shaped convector of the male palp. The gender is feminine.

Diagnosis: The genus contains medium-sized linyphiid spiders, with a total length of 2.21-2.43, which are characterized by the following combination of somatic and genitalic characters:

1) Carapace unmodified; eyes normal, not enlarged; cephalic pits (= sulci) absent (Figs 1-3, 5-6).
2) Legs relatively long and slender, with a distinct colour pattern (Fig. 1).
3) Metatarsi I-III each with a trichobothrium; TmI 0.23-0.25.
4) Paracymbium strongly reduced, poorly sclerotized, almost transparent (Figs 8, 10, 12, 14).
5) Suprategulum and distal suprategular apophysis absent.
6) Tegular apophysis and tegular prominence present (Figs 8, 12-13, 15).
7) Median membrane reduced.
8) Convector present, massive, strongly sclerotized, supplied with a membrane (Figs 8-9,11-13, 16).
9) Embolus small, of the join-type (= Anschluss-Embolus *sensu* Wiehle, 1960) (Figs 11, 16).

Species included: *Himalafurca martensi* sp. nov. and *H. schawalleri* sp. nov.

Taxonomic remarks: In its habitus and especially in its male palpal structure the new genus resembles *Ketambea* Millidge & Russell-Smith, 1992, *Prosoponoides* Millidge & Russell-Smith, 1992 and *Plectembolus* Millidge & Russell-Smith, 1992, which are distributed mainly in the Oriental Region. These genera of unclear subfamily affiliation possess some characters of the subfamilies Linyphiinae and Dubiaraneinae. The main character that brings these genera (including the new one) closer to representatives of the Dubiaraneinae is that the function of the radix is taken on by a convector (for details see Tanasevitch, 2019e, 2020b). *Himalafurca* gen. nov. differs by a very short, join-type embolus (= Anschluss-Embolus *sensu* Wiehle, 1960), contra an insertion-type (= Einführungs-Embolus, op.cit.) in the genera mentioned above. Besides that, the new genus differs by the absence of the suprategulum and of the distal suprategular apophysis, and by the presence of a tegular apophysis (*sensu* Millidge, 1995). This apophysis, erroneously called the distal suprategular apophysis in Tanasevitch (2019e), arises from the internal, median part of the tegulum and is also known from *Racata* Millidge, 1995, a genus of equally obscure affiliation. The tegular apophysis ends with a small hook and obviously has the same engaging function as the distal suprategular apophysis (*sensu* Hormiga, 2000) by interlocking the male and female genitals during copulation. A similar outgrowth on the tegulum, the "mynoglenine tegular apophysis" (*sensu* Hormiga, 1994), is present in mynoglenine genera (see Blest, 1979). In contrast to *Himalafurca* gen. nov. and *Racata*, the mynoglenine tegular apophysis is situated on the edge of the tegulum, at the same position as the suprategulum, but it probably is not homological (for details see Hormiga, 1994). In addition, there is a prominence on the tegulum of *Himalafurca* gen. nov. which resembles the tegular prominence (*sensu* Blest, 1979) known in Mynogleninae. The new genus combines Dubiaraneinae and Mynogleninae characters and thus its position within the family Linyphiidae is unclear at the moment.

Distribution: The Nepal Himalayas.

Himalafurca martensi sp. nov.

Figs 1-4, 8-11

Holotype: SMF; male [sample #390]; NEPAL, Sankhua Sabha District, Thudam, mixed forest, mainly *Betula* & *Rhododendron* forest, 3550-3650 m a.s.l.; 25-27.V.1988; leg. J. Martens & W. Schawaller.

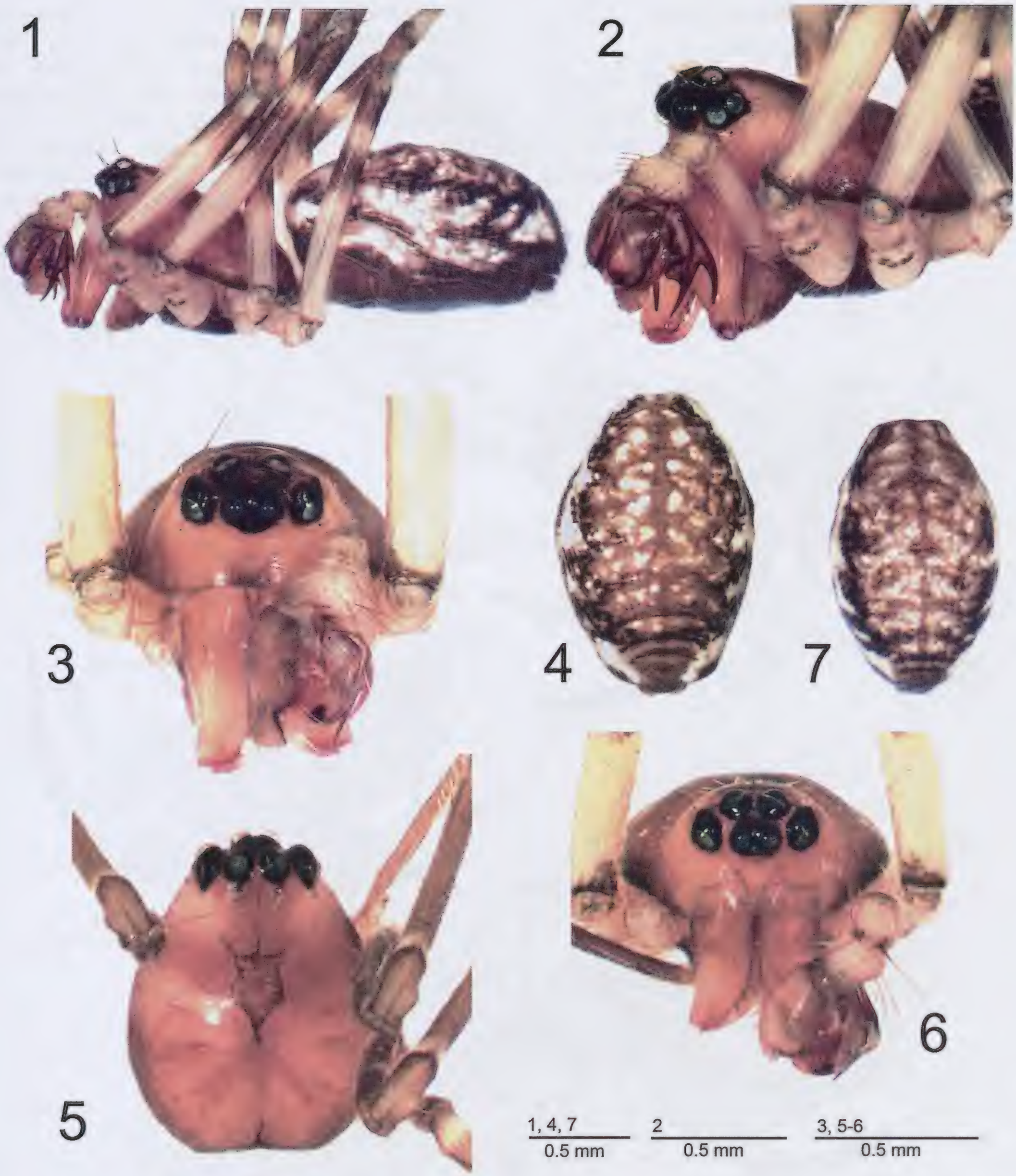
Etymology: The specific epithet is a patronym honouring the renowned German arachnologist and ornithologist Jochen Martens who collected the type specimen of this species.

Diagnosis: The new species is very closely related to its single known congener, *Himalafurca schawalleri* sp. nov., clearly distinguished by a less massive convector with thinner branches, by the two times longer tegular apophysis, as well as by the shape of the paracymbium.

Description: *Male holotype*. Total length 2.43. Carapace unmodified (Figs 1-3), 1.13 long, 0.95 wide, greyish pale brown, with a grey polygonal spot in its centre, and with a narrow, dark grey margin. Eyes normal, not enlarged. Chelicerae 0.53 long; mastidion absent. Legs yellow, with wide, dark brown or almost black rings. Leg I 6.79 long (1.68 + 0.38 + 1.63 + 1.95 + 1.15), IV 4.66 long (1.25 + 0.30 + 1.10 + 1.33

+ 0.68). Chaetotaxy. FeI: 1-2-0-0, II: 1-0-0-0, III-IV: 0-0-0-0; TiI: 2-1-1-1, II: 2-0-1-1, III: 2-0-1-1; IV: 2-1-1(0)-0; MtI: 0-0-1-0, II: 1-1-0-0, III: 1-0-0-0, IV: 0-0-1-0. Length of tibial spines 2-3 times diameter of corresponding leg segment. TmI 0.23. Metatarsus IV without trichobothrium.

Palp (Figs 8-11): Patella short, without conical projecting, bearing a weak spine dorsally. Tibia rounded, unmodified. Paracymbium small and narrow, L-shaped, almost transparent, paracymbial pockets (*sensu* Saaristo & Tanasevitch, 1996) absent. Tegulum with a prominence on its lower edge. Tegular apophysis very long, straight, narrow, arising from internal, median part of tegulum, ending with a small hook. Convector huge, heavily sclerotized, distally bifurcated into long, strong branches. Convector membrane arising from proximal



Figs 1-7. Photographs of the male holotype of *Himalafurca martensi* sp. nov. (1-4) and of the male holotype of *H. schawalleri* sp. nov. (5-7). (1) Habitus, lateral view. (2) Prosoma, fronto-lateral view. (3, 6) Same, frontal view. (5) Same, dorsal view. (4, 7) Abdomen, dorsal view.

part of sclerite near base of embolus, proximally bent. Embolus small, of join-type, with unclear but complex shape. Abdomen 1.40 long, 0.85 wide, dorsal pattern as in Fig. 4.
Female. Unknown.

Distribution: Known only from the type locality, Thudam in Eastern Nepal.

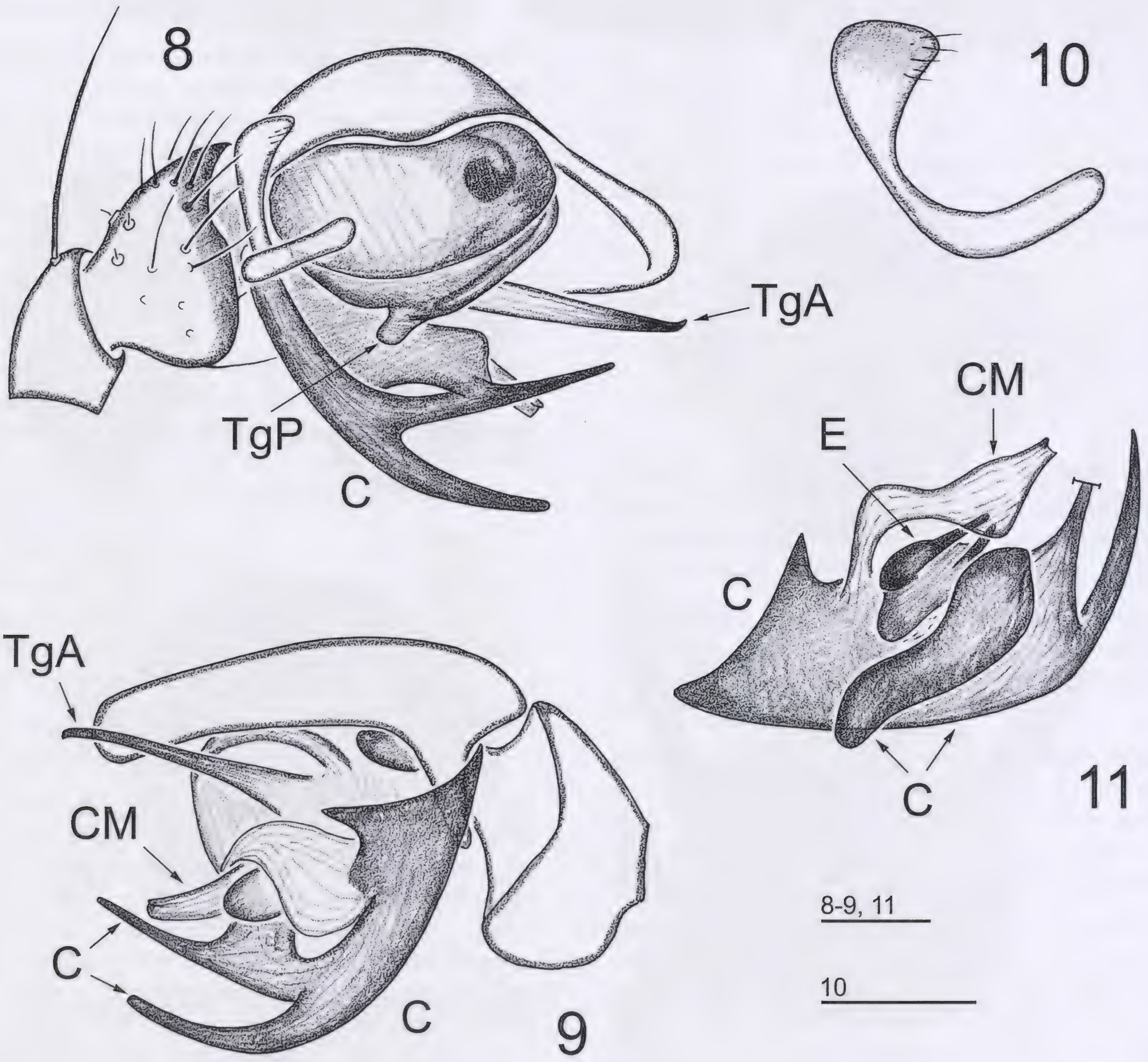
***Himalafurca schawalleri* sp. nov.**
Figs 5-7, 12-16

Holotype: SMF; male [sample #383]; NEPAL, Taplejung District, Ladza Kharka in Ladza Khola, NW of Walungchung (= Olangchung) Gola, 4100-4200 m a.s.l., dwarf *Rhododendron*, creeping *Juniperus*; 21-23.V.1988; leg. J. Martens & W. Schawaller.

Etymology: The new species is named for the German arachnologist and coleopterologist Wolfgang Schawaller who, together with Jochen Martens, collected the type specimen.

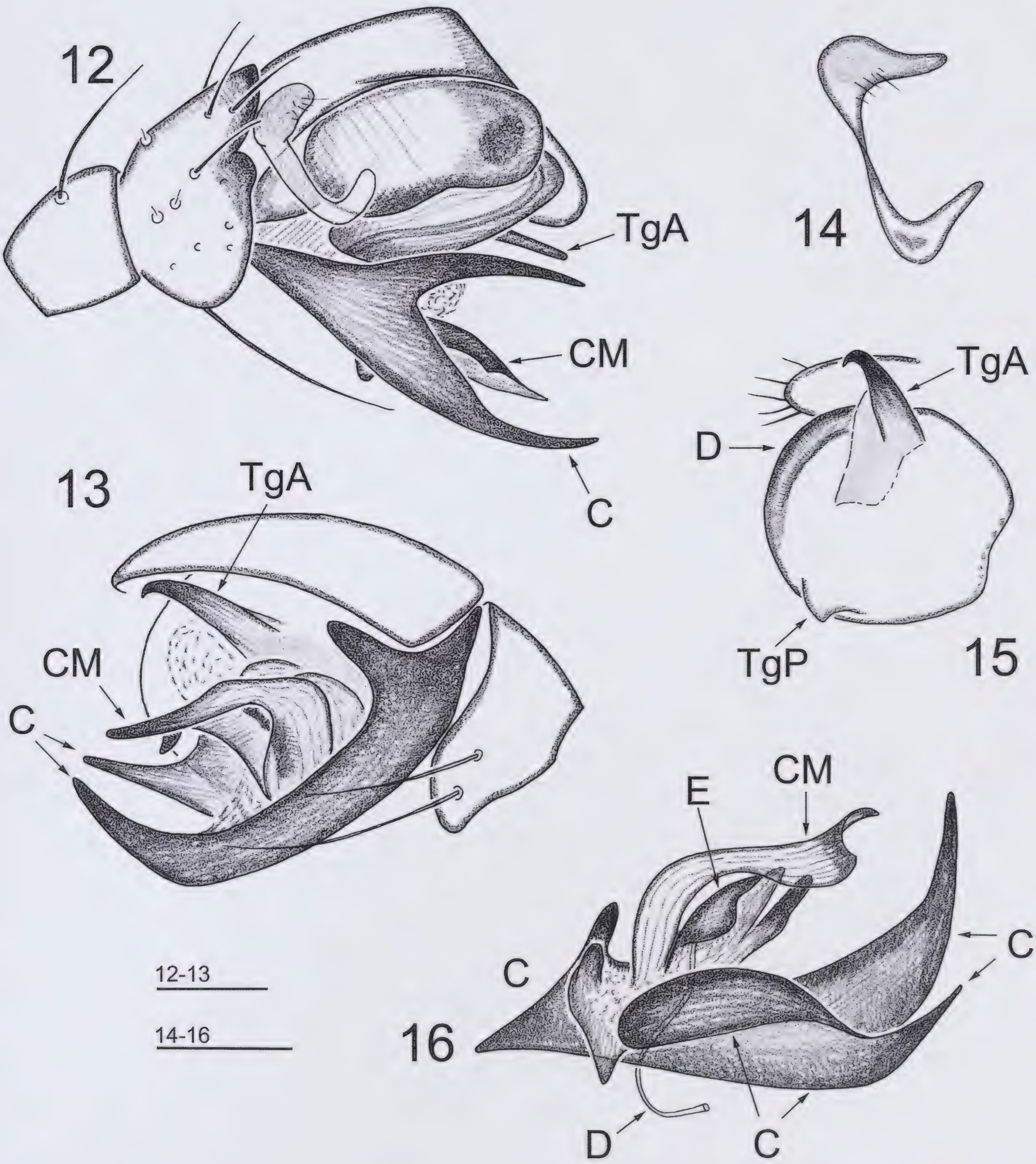
Diagnosis: The new species is very closely related to the type species, *H. martensi* sp. nov.; see its diagnosis for details.

Description: *Male holotype*. Total length 2.21. Carapace unmodified (Figs 5-6), 1.00 long, 0.80 wide, greyish pale brown, with a dark polygonal spot in its centre, and with a narrow, dark grey margin. Eyes normal, not enlarged. Chelicerae 0.38 long; mastidion absent. Legs yellow, with wide, dark brown or almost black rings. Leg I 6.13 long (1.49 + 0.33 + 1.48 + 1.83 + 1.00), IV 4.14 long (1.13 + 0.25 + 0.93 + 1.15 + 0.68). Chaetotaxy. FeI: 1-2-0-0, II: 1-0-0-0, III-IV: 0-0-0-0; TiI: 2-1-1-1, II: 2-0-1-0(1), III: 2-0-1-



Figs 8-11. Details of the right palp of the male holotype of *Himalafurca martensi* sp. nov. (8-9) Distal part of palp, retrolateral and prolateral view, respectively. (10) Paracymbium, prolateral view. (11) Embolic division, mesal view.

1; IV: 2-1-0-0; MtI: 1-1-0-0, II: 1-0-1-0, III: 1-1-0-0, IV: 1-1-0-0. Length of tibial spines 2-3 times diameter of corresponding leg segment. TmI 0.25. Metatarsus IV without trichobothrium. Palp (Figs 12-16): Patella short, without conical projecting, bearing a weak spine dorsally. Tibia unmodified, its retrolateral edge with a small invagination. Paracymbium small and narrow, [-shaped, almost transparent, paracymbial pockets (*sensu* Saaristo & Tanasevitch, 1996) absent. Tegular prominence small (hidden by convector in Fig. 12). Tegular apophysis relatively short and wide, arising from internal, median part of tegulum, ending with a small hook. Convector huge, heavily sclerotized, distally bifurcated into long, strong branches. Convector membrane arising from proximal part of sclerite near base of embolus, bent in middle and sclerotized distally.



12-13

14-16

Figs 12-16. Details of the right palp of the male holotype of *Himalafurca schawalleri* sp. nov. (12-13) Distal part of palp, retrolateral and prolateral view, respectively. (14) Paracymbium, prolateral view. (15) Tegulum, prolateral view (embolic division removed). (16) Embolic division, mesal view.

Embolus small, of join-type, with unclear but complex shape. Abdomen 1.25 long, 0.80 wide, dorsal pattern as in Fig. 7.
Female. Unknown.

Distribution: Known only from the type locality, Olangchung Gola in Eastern Nepal.

FAUNISTICS

Agyneta pakistanica Tanasevitch, 2011

Material examined: MHNG; 1 male; NEPAL, Dailekh District, Dailekh, champs (= in fields), 650 m a.s.l., pitfall traps; 27.III.1980; leg. P. Galland.

Remarks: This species was originally described from two male specimens from the environs of Islamabad, Pakistan, at an altitude of about 550 m a.s.l (Tanasevitch, 2011). In the Nepal Himalayas this species has also been found in the lowlands. *Agyneta pakistanica* is here reported for Nepal and the Himalayas for the first time.

Anguliphantes nepalensis (Tanasevitch, 1987)

Material examined: MHNG; 1 female [sample #27]; NEPAL, Goropani, between Kali Gandaki Valley and Pokhara, north face, 2750 m a.s.l., clearing in forest, sifting rotten wood and leaves along dead oak trunk; 5.X.1983; leg. I. Löbl & A. Smetana. – MHNG; 1 male [sample #31]; Punhill near Goropani, forest between the Kali Gandaki Valley and Pokhara, 3050-3100 m a.s.l., edge of *Rhododendron* and fir forest, sifting mosses and dead leaves; 8.X.1983; leg. I. Löbl & A. Smetana. – MHNG; 1 female [sample #5]; Sankhuwasawa District, Kosi Province, forest northeast of Kuwapani, 2350 m a.s.l., sifting dead leaves and humus near spring; 5.IV.1984; leg. I. Löbl & A. Smetana.

Remarks: This species is widespread in Nepal, at 1450-3600 m a.s.l. (Tanasevitch, 1987 and new data). It was recorded from the Pakistani Himalayas, at 1450 m a.s.l., as well as from Uttar Pradesh, at 1900 m a.s.l., and from West Bengal in India, at 2500-2600 m a.s.l. (Tanasevitch, 2011).

Bathyphantes paracymbialis Tanasevitch, 2014a

Material examined: SMF; 1 male, 3 females [sample #408]; NEPAL, Sankhua Sabha District, Arun Valley bottom between Hedangna and Num, subtropical forest, 950-1000 m a.s.l.; 6-8.VI.1988; leg. J. Martens & W. Schawaller. – SMF; 3 males, 4 females [sample #351]; Taplejung District, Yamputhin, cultivated land, open forest, 1650-1800 m a.s.l.; 26.IV.-1.V.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is widespread in continental and insular parts of the Oriental Region (Tanasevitch, 2019d). In Nepal and Xishuangbanna, Yunnan Province, China (Zhao & Li, 2014) the northern limit of its geographical range is close to the Palaearctic Region. *Bathyphantes paracymbialis* is here reported for Nepal and the Himalayas for the first time.

Caviphantes pseudosaxetorum Wunderlich, 1979

Material examined: MHNG; 2 females [sample #5]; NEPAL, Kosi Province, Sankhuwasawa District, forest northeast of Kuwapani, 2350 m a.s.l., sifting dead leaves and humus near source; 5.IV.1984; leg. I. Löbl & A. Smetana. – MHNG; 3 males [sample #9]; ridge south of Mangsingma, 2800 m a.s.l., sifting bamboo leaves and rhododendrons; 7.IV.1984; leg. I. Löbl & A. Smetana. – MHNG; 2 males [sample #22]; Induwa Kola Valley, 2800 m a.s.l., sifting dead leaves of rhododendrons and bamboo at foot of rocks; 15.IV.1984; leg. I. Löbl & A. Smetana. – MHNG; 1 female [sample #24a]; Induwa Kola Valley, 2000 m a.s.l., sifting moss and dead leaves on swampy terrain; 16.IV.1984; leg. I. Löbl & A. Smetana. – MHNG; 1 male [sample #27]; same locality, sifting mosses and dead leaves at foot of cliff, 2100 m a.s.l.; 17.IV.1984; leg. I. Löbl & A. Smetana. – MHNG; 1 male [sample #30b]; Goropani, forest between Kali Gandaki Valley and Pokhara, ridge east of Goropani, 3100 m a.s.l., sifting at foot of huge fir tree at edge of small swamp; 7.X.1983; leg. I. Löbl & A. Smetana. – SMF; 1 female [sample #142]; NEPAL, Manang District, Marsyandi Valley, between Thanjok and Chame, 2550 m a.s.l., close to a rivulet; 17.IV.1980; leg. J. Martens & A. Ausobsky. – SMF; 2 males, 8 females [sample #328]; Panchthar District, Paniporua, 2300 m a.s.l., mixed broad-leaved forest; 16-20.IV.1988; leg. J. Martens & W. Schawaller. – SMF; 4 females [sample # 404]; above Pahakhola, 2600-2800 m a.s.l., *Quercus semecarpifolia*, *Rhododendron*; 31.V.1988; leg. J. Martens & W. Schawaller. – SMF; 2 males [sample #412]; Sankhuassabha District, Arun Valley between Mure and Hurure, 2050-2150 m a.s.l., mixed broad-leaved forest; 9-17.VI.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is widely distributed in the southern Palaearctic eastward of the Mediterranean Sea, as well as in continental and insular parts of the Oriental Region (World Spider Catalog, 2020). In Nepal *C. pseudosaxetorum* occurs at 550-3100 m a.s.l. (Wunderlich, 1979 and new data).

Claviphantes bifurcatus (Tanasevitch, 1987)

Material examined: MHNG; 1 male, 1 female [sample #33]; NEPAL, Kosi Province, Sankhuwasawa District,

Goropani, Nandanda, northeast of Pokhara, forest between the Kali Gandaki Valley and Pokhara, 1300-1400 m, on vegetation; 11.X.1983; leg. I. Löbl & A. Smetana.

Remarks: This species known only from Nepal where it occurs at 1300-3100 m a.s.l. (Tanasevitch, 1987; Tanasevitch & Saaristo, 2006 and new data).

Erigone prominens Bösenberg & Strand, 1906

Material examined: MHNG; 3 males (specimens dried up), NEPAL, Dailekh District, Dailekh, champs (= in fields), 650 m a.s.l., pitfall traps; 27.III.1980; leg. P. Galland. – SMF; 1 male [sample #119]; NEPAL, Ilam District, Gitang Khola, 1900 m a.s.l., Bachaue I'Bach; 27.III.1980; leg. J. Martens & A. Ausobsky. – SMF; 1 male [sample #140a]; Manang District, Marsyandi, Thimang, 2550 m a.s.l., *Tsuga*, *Acer* and *Rhododendron* forest, Berlese extraction; 14-17.IV.1980; leg. J. Martens & A. Ausobsky.

Remarks: This species is widespread in southern Asia, introduced to Africa, Australia and New Zealand (World Spider Catalog, 2020). In Nepal it has been reported under *Erigone* cf. *ourania* Crosby & Bishop, 1928 by Wunderlich (1983). Taking into account the new data, it occurs there at 1900-3200 m a.s.l.

Fistulaphantes canalis Tanasevitch & Saaristo, 2006

Material examined: MHNG; 3 females [sample #8b]; NEPAL, Sankhuwasawa District, Kosi Province, ridge northeast of Mangmaya, 2800 m a.s.l., northwest face, sifting bamboo leaves and rhododendrons near source; 7.IV.1984; leg. I. Löbl & A. Smetana. – MHNG; 1 male, 1 female [sample #24a]; Induwa Kola Valley, 2000 m a.s.l., sifting mosses and dead leaves on marshland; 16.IV.1984; leg. I. Löbl & A. Smetana. – SMF; 1 male, 5 females [sample #404]; NEPAL, Sankhuasabha District, above Pahakhola, 2600-2800 m a.s.l., *Quercus semecarpifolia* and *Rhododendron* forest; 31.V.1988; leg. J. Martens & W. Schawaller. – SMF; 1 female [sample #412]; Arun Valley between Mure and Hurure, 2050-2150 m a.s.l., mixed broad-leaved forest; 9-17.VI.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is known only from Nepal, at altitudes of 2000-3650 m a.s.l. (Tanasevitch & Saaristo, 2006 and new data).

Gnathonarium gibberum Oi, 1960

Material examined: SMF; 1 male [sample #338]; NEPAL, Taplejung District, from Iwa Khola Bridge to Sablako Pass, 940-1200 m a.s.l., stream bank; 22.IV.1988; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample #200]; Kathmandu-Tal, Ganabahal and Baneshwar, cultural land, 1350 m a.s.l.; 17-20.VII.1980; leg. J. Martens & W. Schawaller.

Remarks: This species is known from South Siberia, Russia, China, Korea, Japan (World Spider Catalog, 2020). *Gnathonarium gibberum* is here reported for Nepal and the Himalayas for the first time.

Gongylidiellum nepalense Wunderlich, 1983

Material examined: SMF; 6 males, 4 females [sample #324]; NEPAL, Panchthar District, Dhorpar Kharka, *Rhododendron* and *Lathocarpus* forest, 2700 m a.s.l.; 13-16.IV.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is widespread in the Nepal Himalayas, at 2500-3400 m a.s.l. (Wunderlich, 1983), and it was reported from West Bengal, India, at 2700-3100 m a.s.l. (Tanasevitch, 2011 and new data).

Halorates crassipalpis (Caporiacco, 1935) comb. nov.

Gongylidium crassipalpe Caporiacco, 1935: 171, pl. III, fig. 3a-b; male lectotype examined.
Collinsia japonica (Oi, 1964). – Wunderlich, 1983: 231, misidentification; male and female syntypes examined.
For a full synonymy list see World Spider Catalog (2020).

Type material examined: MCSNM; male lectotype of *Gongylidium crassipalpe* Caporiacco, 1935, designated by K. Thaler in 1987; Pakistan, Mts Karakorum, Olthingthang, 2600 m a.s.l.; 13.IV.1929. – NSMT; 1 female syntype (Ar. 2725), 1 male and 1 female syntypes (Ar. 2726) of *Scotargus japonicus* Oi, 1964; Japan, Ishkawa Prefecture, Mt Hakusan; 2.VIII.1961; leg. H. Tokumoto, det. R. Oi.

New material examined: SMF, No. 31674; 4 females; NEPAL, S of Annapurna-Massif, Pass Gorapani, 2700-2800 m a.s.l.; 23.II.1974; leg. J. Martens. – SMF, No. 31670; 2 males; S of Dhaulagiri-Massif, Dhorpatan, 3000 m a.s.l.; 24.V.1973; leg. J. Martens. – SMF, No. 31671; 1 female; W of Dhaulagiri-Massif, road from Dhorpatan to Tarakot, via resting place Dhule and Sheng Khola, 3100-3600 m a.s.l.; 30.V.1973; leg. J. Martens. – SMF, No. 31672; 2 females; northern Dhaulagiri Massif, Dolpo, valley of the upper Barbung Khola, Charka, 4300 m a.s.l.; 24-29.VI.1973; leg. J. Martens. – SMF, No. 31673; 1 female; Thakkhola, Breakthrough Valley of the Kali-Gandaki through Himalayan main chain, valley of Chadziou-Khola close to Ghasa, 2600 m a.s.l.; IX.1969; leg. J. Martens. All specimens labeled as *Collinsia japonica*, det. Wunderlich, 1979. – SMF; 1 male [sample #235]; Gorkha District, Chuling Khola, S of Kalo Pokhlari, 3600 m a.s.l., *Betula* forest on moraine; 7.VIII.1983; leg. J. Martens & W. Schawaller. – SMF; 1 female

[sample #319]; Ilam District, Mai Pokhlari, *Castanopsis* forest remains, 2100-2200 m a.s.l.; 9-10.IV.1988; leg. J. Martens & W. Schawaller. – SMF; 1 male, 1 female [sample #377]; Taplejung District, upper Tamur Valley, below Walungchung Gola, mixed forest, open river bank, 2400-2700 m a.s.l.; 20.V.1988; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample #378]; upper Tamur Valley, Walungchung Gola, *Tsuga* forest, mainly open river terraces, 3000-3200 m a.s.l.; 20.V.1988; leg. J. Martens & W. Schawaller. All specimens labeled as *Halorates japonicus*, det. A. Tanasevitch, 2016. – SMF; 1 male, 1 female [sample #377]; Taplejung District, below Walungchung (= Olangchung) Gola, mixed forest, open river bank, 2400-2700 m a.s.l.; 20.V.1988; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample #169]; Parbat District, Chitre, 2400 m a.s.l., streambed with bushes; 4.V.1980; leg. J. Martens & A. Ausobsky. – SMF; 1 female [sample #319a]; Ilam District, Worebung Pass, degraded broad-leaved forest, 2000 m a.s.l.; 21.IV.1988; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample #378]; upper Tamur Valley, Walungchung (= Olangchung) Gola, *Tsuga* forest, mainly open river terraces, 3000-3200 m a.s.l.; 20.V.1988; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample #274]; ascent to the ridge Lasse Dhara, mixed forest, 2500-2800 m a.s.l.; 6.IX.1983; leg. J. Martens & B. Daams.

Remarks: This species was originally described under *Gongylidium* Menge, 1868 from the Karakorum by Caporiacco (1935). Later a lectotype was designated for *G. crassipalpe*, and the species was revised and transferred to *Milleriana* Denis, 1966 (see Thaler, 1987). Subsequently the genus *Milleriana* was synonymized with *Collinsia* (see Eskov, 1990) and the species name began to be cited as *Collinsia crassipalpis*. In spider material from Nepal, collected during Prof. Jochen Martens' expeditions, Wunderlich (1983) identified several specimens of *Scotargus japonicus* Oi, 1960, a species which was previously known only from Japan, and he quite rightly at that moment transferred it to *Collinsia*. My examination of the type specimens of *Collinsia japonica* and *C. crassipalpis*, however, showed that all specimens from Nepal identified as *C. japonica* (see above) in fact belong to *C. crassipalpis*.

I agree with Buckle *et al*. (2001) that the genus *Collinsia* O. Pickard-Cambridge, 1913 is a junior synonym of *Halorates* Hull, 1911 (for details see Tanasevitch, 2009), thus *Halorates crassipalpis* comb. nov. is here transferred from *Collinsia*.

This species is presently known from the Karakorum, at 2400-2600 m a.s.l. (Caporiacco, 1935, under *Gongylidium*), and it is widespread in Nepal, where it occurs at 2000-4300 m a.s.l. (Wunderlich, 1983, under *Collinsia japonica*, and new data).

"*Hilaira*" *dapaensis* Wunderlich, 1983

Material examined: SMF; 1 male, 1 female [sample #385]; NEPAL, Taplejung District, ascent to Tangje La, NW Walungchung (= Olangchung) Gola, 4800-5000 m a.s.l., below stones under snow, alpine steppe; 23.V.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is still of unclear generic affiliation, reported only from Nepal, at 4800-5100 m a.s.l. (Wunderlich, 1983 and new data).

Himalaphantes grandiculus (Tanasevitch, 1987)

Material examined: SMF; 1 male, 1 female [sample #324]; NEPAL, Panchthar District, Dhorpar Kharka, *Rhododendron* and *Lathocarpus* forest, 2700 m a.s.l.; 13-16.IV.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is known only from Nepal, at 2000-4200 m a.s.l. (Tanasevitch, 1987 and new data).

Hubertella montana Tanasevitch, 2019b

Material examined: MHNG; 1 male [sample #9]; NEPAL, Bagmati Province, above Gul Bhanjyang, 2600 m a.s.l., old oak grove on the north slope, steep slope, sifting dead leaves, moss and rotten wood, at foot of trees; 6.IV.1981; leg. I. Löbl & A. Smetana.

Remarks: This species is known only from Nepal, at 2450-2700 m a.s.l. (Tanasevitch, 2019b and new data).

Mughiphantes ancoriformis (Tanasevitch, 1987)

Material examined: SMF; 2 females [sample #361]; NEPAL, Taplejung District, upper Simbua Khola Valley, near Tseram, 3250-3350 m a.s.l., mature *Abies-Rhododendron* forest; 10-15.V.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is known only from Nepal, at 3200-3350 m a.s.l. (Tanasevitch, 1987 and new data).

Nasoona asocialis (Wunderlich, 1974)

Material examined: MHNG; 1 male [sample #1c]; NEPAL, Kathmandu District, Godawari, 1600 m a.s.l., sifting mosses and dead leaves at foot of shrubs, fairly dry; 31.III.1984; leg. I. Löbl & A. Smetana. – SMF; 5 females [sample #116]; NEPAL, Ilam District, Mai Pokhari, 2100-2200 m a.s.l., forest; 25-27.III.1980; leg. J. Martens & A. Ausobsky. – SMF; 1 male [sample #185]; between Mai Pokhari and Ilam, 1330 m a.s.l., slope with spring, cultural land; 1.IV.1980; leg. J. Martens & A. Ausobsky. – SMF; 1 male, 2 females [sample #135]; Lamjung District, Marsyand, Jagat,

1200 m a.s.l., Berlese extraction, mixed broad-leaved forest; 11.IV.1980; leg. J. Martens & A. Ausobsky. – SMF; 1 male [sample # 203a]; Kathmandu Valley, Nagarjun, Jamacok, secondary forest, Berlese extraction, 1400-1600 m a.s.l.; 18.VIII.1983; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample #204]; same locality, 1900-2100 m a.s.l., secondary forest; 18.VIII.1983; leg. J. Martens & W. Schawaller. – SMF; 3 females [sample #206]; Nuwakot District, forest between Kathmandu and Trishuli; 21.VII.1983; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample #308]; Ilam District, Sanishare, 5 km N, foot of Siwalik Mts, 270-300 m a.s.l., mixed *Shorea* forest; 3-5.IV.1988; leg. J. Martens & W. Schawaller. – SMF; 4 females [sample #356]; Taplejung District, Omje Kharka NW Yamputhin, natural mixed broad-leaved forest, 2300-2500 m a.s.l.; 1-6.V.1988; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample #408]; Sankhua Sabha District, Arun Valley bottom between Hedangna and Num, subtropical forest, 950-1000 m a.s.l.; 6-8. VI.1988; leg. J. Martens & W. Schawaller. – SMF; 3 females [sample #344]; Taplejung District, confluence of Kabeli Khola and Tada Khola, 1000 m a.s.l., mixed broad-leaved forest; 23-25.IV.1988; leg. J. Martens & W. Schawaller.

Remarks: *Nasoona asocialis* was described from a female from the Nepal Himalayas, and originally placed in *Oedothorax* Bertkau in Förster & Bertkau, 1883 by Wunderlich (1974). Later this species was described for a second time as *Gorbothorax ungibbus* Tanasevitch, 1998a based on a single male from the same mountain territory (Tanasevitch, 1998a). The species is widely distributed in the Oriental Region: Nepal, India (Wunderlich, 1974; Tanasevitch, 1998a, 2011), Laos, Thailand, West Malaysia (Tanasevitch, 2014a, b), Myanmar, Indonesia (Bali, Java; Tanasevitch, 2017), northern Vietnam (Tu & Li, 2004, under *Walckenaeria caobangensis* Tu & Li, 2004), and in Xishuangbanna, southern China (Zhao & Li, 2014). In Nepal *N. asocialis* occurs in lowlands and midlands, at 270-2500 m a.s.l. (Wunderlich, 1974; Tanasevitch, 1998a and new data).

Nematogmus dentimanus Simon, 1886

Material examined: SMF; 1 male, 1 female [sample #406]; NEPAL, Sankhua Sabha District, between Pahakhola and Karmarang, 1800-1500 m a.s.l., cultural land, bushes; 4.VI.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is widely distributed in the Oriental Region, from Sri Lanka to Malaysia, Indonesia (Java, Krakatau) (World Spider Catalog, 2020). *Nematogmus dentimanus* is here reported for Nepal and the Himalayas for the first time.

Neriene oidedicata Helsdingen, 1969

Material examined: SMF; 1 male [sample #329]; NEPAL, Panchthar District, between Paniporua and Hinwa Khola Valley, 1850-2300 m a.s.l., cultivated land, tree-rich; 20.IV.1988; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample #351]; Taplejung District, Yamputhin, cultivated land, open forest, 1650-1800 m a.s.l.; 26.IV.-1.V.1988; leg. J. Martens & W. Schawaller. – SMF; 1 male [sample # 352]; above Yamputhin, left bank of Kabeli Khola, bushes, open forest, 1800-2000 m a.s.l.; 27-29.IV.1988; leg J. Martens & W. Schawaller.

Remarks: This species is distributed in the south-eastern part of the Palaearctic: Russian Far East, China, Korea, Japan (World Spider Catalog, 2020). In Nepal *N. oidedicata* was reported from 1600 to 2300 m a.s.l. (Wunderlich, 1983 and new data).

Oedothorax dismodicoides Wunderlich, 1974

Material examined: MHNG; 1 male [sample #27]; NEPAL, Myagdi District, Ghodepani, Goropani forest, between Kali Gandaki Valley and Pokhara, north face, 2750 m a.s.l., clearing in forest, sifting of rotten wood and leaves along dead trunk of *Quercus*; 5.X.1983; leg. I. Löbl & A. Smetana. – MHNG; 1 male [sample #30b]; Goropani Forest, between Kali Gandaki Valley and Pokhara, ridge east of Goropani, 3100 m a.s.l., sifting at foot of huge fir tree, on edge of small swamp; 7.X.1983; leg. I. Löbl & A. Smetana.

Remarks: This species is known only from Nepal, at 2460-3350 m a.s.l. (Wunderlich, 1974 and new data).

Oedothorax elongatus Wunderlich, 1974

Material examined: MHNG; 1 male [sample #5]; NEPAL, Bagmati Province, above Chaubas, 2500 m a.s.l., *Rhododendron* forest, sifting dead leaves and ferns in small ravine; 4.IV.1981; leg. I. Löbl & A. Smetana.

Remarks: This species is known only from Nepal, at 2000-2500 m a.s.l. (Wunderlich, 1974 and new data).

Oia sororia Wunderlich, 1973

Material examined: MHNG; 1 male, 3 females [sample #27]; NEPAL, Myagdi District, Ghodepani, Goropani, forest between Kali Gandaki Valley and Pokhara, north face, 2750 m a.s.l., clearing in forest, sifting of rotten wood and leaves along dead trunk of *Quercus*; 5.X.1983; leg. I. Löbl & A. Smetana. – SMF; 1 female [sample #140a]; NEPAL, Manang District, Marsyandi, 2550 m a.s.l., Thimang, Berlese extraction, *Tsuga-Acer-Rhododendron* forest; 14-17.IV.1980; leg.

J. Martens & A. Ausobsky. – SMF; 5 females [sample # 142]; Marsyandi Valley, between Thanjok and Chame, 2550 m a.s.l., close to a rivulet; 17.IV.1980; leg. J. Martens & A. Ausobsky. – SMF; 2 females [sample #161a]; S of Lethe, 2450-2600 m a.s.l., Berlese extraction, abundant mixed broad-leaved forest; 30.IV.-1.V.1980; leg. J. Martens & A. Ausobsky.

Remarks: This species is known from Nepal, at 2000-2750 m a.s.l. (Wunderlich, 1974 and new data) and from West Bengal, India, at 2000 m a.s.l. (Tanasevitch, 2011).

Oia kathmandu Tanasevitch, 2019b

Material examined: MHNG; 6 females [sample #54]; NEPAL, Bagmati Province, Dobate Ridge northeast of Barahbise, 2700 m a.s.l., sifting of dead leaves and mosses in oak grove; 2.V.1981; leg. I. Löbl & A. Smetana. – MHNG; 7 females [sample #55d]; same locality, 2800 m a.s.l., sifting rotten wood, dead leaves and moss in oak grove with *Rhododendron*; 2.V.1981; leg. I. Löbl & A. Smetana. – MHNG; 3 females [sample #63]; same locality, 2700 m a.s.l., sifting of mosses and dead leaves at edge of oak grove; 7.V.1981; leg. I. Löbl & A. Smetana. – MHNG; 3 males, 3 females [sample #356]; Taplejung District, Omje Kharka NW Yamputhin, natural mixed broad-leaved forest, 2300-2500 m a.s.l.; 1-6.V.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is known only from Nepal, at 1800-2800 m a.s.l. (Tanasevitch, 2019b and new data).

Paragongylidiellum caliginosum Wunderlich, 1973

Material examined: SMF; 14 males, 29 females [sample #161a]; NEPAL, Mustang District, S of Lethe, 2450-2600 m a.s.l., rich mixed deciduous forest, Berlese extraction; 30.IV.-1.V.1980; leg. J. Martens & A. Ausobsky. – SMF; 3 males, 14 females [sample #412]; Sankhua Sabha District, Arun Valley between Mure and Hurure, 2050-2150 m a.s.l., mixed broad-leaved forest; 9-17.VI.1988; leg. J. Martens & W. Schawaller. – MHNG; 1 female [sample #7b]; NEPAL, Bagmati Province, Burlung Bhanjyang, 2600 m a.s.l., sifting mosses and dead leaves near source; 5.IV.1981; leg. I. Löbl & A. Smetana. – MHNG; 1 male [sample #23]; Malemchi, 2900 m a.s.l., steep slope near river, sifting dead leaves of rhododendrons, oaks and chestnuts; 14.IV.1981; leg. I. Löbl & A. Smetana. – MHNG; 2 females [sample #25]; Mustang and Kali Gandaki valley, forest above Lethe, 2550 m a.s.l., sifting rotten wood, dead leaves and moss; 2.X.1983; leg. I. Löbl & A. Smetana. – MHNG; 1 male [sample # 27]; Myagdi District, Ghodepani, Goropani forest, between Kali Gandaki Valley and Pokhara, north face, 2750 m a.s.l., clearing in forest, sifting of rotten wood and leaves along dead trunk of *Quercus*; 5.X.1983; leg. I. Löbl & A. Smetana. – MHNG; 1 female [sample #37]; Yangri Ridge, 4200 m a.s.l., sifting dead leaves of *Juniperus*, *Lonicera* and *Rhododendron*; 21.IV.1981; leg. I. Löbl & A. Smetana. – MHNG; 5 females [sample #47b]; above Shermathang, 2900 m a.s.l., in excrements; 26.IV.1981; leg. I. Löbl & A. Smetana. – MHNG; 1 male, 2 females [sample #59]; Jangtang Ridge northeast of Barahbise, 3250 m a.s.l., sifting in fir-*Rhododendron* forest; 5.V.1981; leg. I. Löbl & A. Smetana. – MHNG; 1 male [sample #7]; Sankhuwasawa District, Kosi Province, pass northeast of Mangmaya, 2300 m a.s.l., north face, dry forest, sifting wood and leaves; 6.IV.1984; leg. I. Löbl & A. Smetana.

Remarks: This species is known from Nepal, at 1800-4200 m a.s.l. (Wunderlich, 1973, 1983 and new data) and from Tamil Nadu, India, at 700-1250 m a.s.l. (Tanasevitch, 2011, 2019d).

Saloca khumbuensis Wunderlich, 1983

Material examined: SMF; 1 male, 1 female [sample #108]; NEPAL, Kathmandu District, Phulchoki, 2600-2650 m a.s.l., *Quercus semecarpifolia* forest; 21-22.III.1980; leg. J. Martens & A. Ausobsky. – MHNG; 1 male [sample #29a]; Myagdi District, Ghodepani, Ghodepani, forest between Kali Gandaki Valley and Pokhara, 2700 m a.s.l., under stones; 6.X.1983; leg. I. Löbl & A. Smetana. – MHNG; 1 male [sample #35]; Kathmandu District, Phulchoki, 2650 m a.s.l., fairly dry forest, sifting mushrooms on dead oak trunks, leaves and rotten wood along trunks; 14.X.1983; leg. I. Löbl & A. Smetana. – MHNG; 1 male [sample #36]; Phulcoki, 2600-2700 m a.s.l., fairly dry forest, sifting mushrooms on dead oak trunks, leaves and rotten wood along trunks; 15.X.1983; leg. I. Löbl & A. Smetana.

Remarks: This species is known only from Nepal, at 2600-2950 m a.s.l. (Wunderlich, 1983 and new data).

Tapinocyba montivaga Tanasevitch, 2019c

Material examined: MHNG; 1 male [sample #12]; NEPAL, Kosi Province, Sankhuwasawa District, Goru Dzure Dara, 3350 m a.s.l., east side, sifting mosses, ferns and herbs; 9.IV.1984; leg. I. Löbl & A. Smetana.

Remarks: This species is known only from Nepal, at 3350-4400 m a.s.l. (Tanasevitch, 2019c and new data).

Tiso aestivus (L. Koch, 1872)

Material examined: SMF; 1 male [sample #383]; NEPAL, Taplejung District, Ladza Kharka in Ladza Khola, NW Walungchung (= Olangchung) Gola, 4100-4200 m a.s.l., dwarf *Rhododendron*, creeping *Juniperus*; 21-23.V.1988; leg. J. Martens & W. Schawaller.

Remarks: This Palaearctic-West Nearctic polyzonal species is here reported for Nepal and the Himalayas for the first time.

Tiso indianus Tanasevitch, 2011

Material examined: SMF; 6 males, 9 females [sample #356]; NEPAL, Taplejung District, Omje Kharka NW Yamputhin, natural mixed broad-leaved forest, 2300-2500 m a.s.l.; 1-6.V.1988; leg. J. Martens & W. Schawaller.

Remarks: This species was originally described from West Bengal, India, at 2500-2600 m a.s.l., (Tanasevitch, 2011). *Tiso indianus* is here reported for the fauna of Nepal for the first time.

Walckenaeria martensi Wunderlich, 1972

Material examined: SMF; 2 females [sample #140a]; NEPAL, Manang District, Marsyandi, 2550 m a.s.l., Thimang, Berlese extraction, *Tsuga*, *Acer* and *Rhododendron* forest; 14-17.IV.1980; leg. J. Martens & A. Ausobsky. – SMF; 1 female [sample #324]; Panchthar District, Dhorpar Kharka, *Rhododendron* and *Lathocarpus* forest, 2700 m a.s.l.; 13-16.IV.1988; leg. J. Martens & W. Schawaller. – SMF; 4 females [sample #328]; Paniporua, 2300 m a.s.l., mixed broad-leaved forest; 16-20.IV.1988; leg. J. Martens & W. Schawaller. – SMF; 1 female [sample #334]; Taplejung District, Worebung Pass, degraded broad-leaved forest, 2000 m a.s.l.; 21.IV.1988; leg. J. Martens & W. Schawaller. – SMF; 1 female [sample #356]; Omje Kharka, NW of Yamputhin, natural mixed broad-leaved forest, 2300-2500 m a.s.l.; 1-6.V.1988; leg. J. Martens & W. Schawaller. – SMF; 1 female [sample #365]; Yamputhin, ascent to Deorali Pass, 2100-2600 m a.s.l., cultural land, bushes; 16.V.1988; leg. J. Martens & W. Schawaller. – SMF; 1 female [sample #404]; Sankhua Sabha District, above Pahakhola, 2600-2800 m a.s.l., *Quercus semecarpifolia*, *Rhododendron*; 31.V.1988; leg. J. Martens & W. Schawaller. – SMF; 1 female [sample #412]; Arun Valley between Mure and Hurure, 2050-2150 m a.s.l., mixed broad-leaved forest; 9-17.VI.1988; leg. J. Martens & W. Schawaller.

Remarks: This species is widely distributed in Nepal, at 2000-3500 m a.s.l. (Wunderlich, 1972, under *Walckenaeria nepalensis* Wunderlich, 1972; Tanasevitch, 2011, under *W. martensi*; new data), and it was also recorded from West Bengal, India, at 3100 m a.s.l. (Tanasevitch, 2011).

CONCLUSION

Taking into account the new data, the linyphiid spider fauna of Nepal currently includes no less than 107 species. The representation of the subfamilies is as follows: Erigoninae (56), Micronetinae (44) and Linyphiinae (7 species). The linyphiid fauna of Nepal is strongly regional. Only 11 of its species (10%) occur outside the Himalayan mountains: *Bathyphantes paracymbialis*, *Caviphantes pseudosaxetorum*, *Erigone atra* Blackwall, 1833, *E. prominens*, *Gnathonarium gibberum*, *Megalepthyphantes nebulosoides* (Wunderlich, 1977), *Nasoona asocialis*, *Nematogmus dentimanus*, *Neriene oidedicata*, *Scotargus pilosus* Simon, 1913 and *Tiso aestivus*. The geographical ranges of the remaining 96 species (90%) seem to be restricted to the Himalayas, and presently these can be considered as Himalayan endemics.

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REFERENCES

Blackwall J. 1833. Characters of some undescribed genera and species of Araneidae. *London and Edinburgh Philosophical Magazine and Journal of Science* (3)3: 104-112, 187-197, 344-352, 436-443.

Blest A.D. 1979. The spiders of New Zealand. Part V. Linyphiidae-Mynoglenidae. *Otago Museum Bulletin* 5: 95-173.

Bösenberg W., Strand E. 1906. Japanische Spinnen. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft* 30: 93-422.

Buckle D.J., Carroll D., Crawford R.L., Roth V.D. 2001. Linyphiidae and Pimoidae of America north of Mexico: checklist, synonymy, and literature. *Fabreries,* Supplement 10: 89-191.

Caporiacco L. di 1935. Aracnidi dell'Himalaia e del Karakoram, raccolti dalla Missione italiana al Karakoram (1929-VII). *Memorie della Società Entomologica Italiana* 13: 161-263.

Crosby C.R., Bishop S.C. 1928. Revision of the spider genera *Erigone*, *Eperigone* and *Catabrithorax* (Erigoneae). *New York State Museum Bulletin* 278: 1-73.

Denis J. 1966. *Milleriana*, a new genus for a British spider (*Scotargus inerrans* O. P.-C.). *Bulletin of the British Spider Study Group* 31: 9.

Eskov K.Y. 1990. The spider genus *Collinsia* O. Pickard-Cambridge 1913 in the fauna of Siberia and the Soviet Far

East (Arachnida: Araneae: Linyphiidae). *Senckenbergiana Biologica* 70: 287-298.

Förster A., Bertkau P. 1883. Beiträge zur Kenntniss der Spinnenfauna der Rheinprovinz. *Verhandlungen des Naturhistorischen Vereins der Preussischen Rheinlande und Westfalens* 40: 205-278.

Georgescu M. 1977. La description d'un nouveau genre d'araignée de Népal, *Hubertia orientalis* n.g., n.sp. (Micryphantidae). *Travaux de l'Institut de Spéologie "Émile Racovitza"* 16: 71-75.

Helsdingen P.J. van 1969. A reclassification of the species of *Linyphia* Latreille based on the functioning of the genitalia (Araneida, Linyphiidae), I. *Zoologische Verhandelingen* 105: 1-303.

Hormiga G. 1994. Cladistics and the comparative morphology of linyphiid spiders and their relatives (Araneae, Araneoidea, Linyphiidae). *Zoological Journal of the Linnean Society* 111: 1-71.

Hormiga G. 2000. Higher level phylogenetics of erigonine spiders (Araneae, Linyphiidae, Erigoninae). *Smithsonian Contributions to Zoology* 609: 1-160.

Hull J.E. 1911. New and rare Brit. spiders. *Transactions of the Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne* (N.S.) 4(1): 42-58, pl. 2.

Koch L. 1872. Beitrag zur Kenntniss der Arachnidenfauna Tirols. Zweite Abhandlung. *Zeitschrift des Ferdinandeums für Tirol und Vorarlberg* (3) 17: 239-328.

Menge A. 1868. Preussische Spinnen. II. Abtheilung. *Schriften der Naturforschenden Gesellschaft in Danzig* (N. F.) 2: 153-218.

Merrett P. 1963. The palpus of male spiders of the family Linyphiidae. *Proceedings of the Zoological Society of London* 140: 347-467.

Millidge A.F. 1995. Some linyphiid spiders from south-east Asia. *Bulletin of the British Arachnological Society* 10: 41-56.

Millidge A.F., Russell-Smith A. 1992. Linyphiidae from rain forests of Southeast Asia. *Journal of Natural History* 26: 1367-1404.

Oi R. 1960. Linyphiid spiders of Japan. *Journal of the Institute of Polytechnics Osaka City University* (Series D) 11: 137-244.

Oi R. 1964. A supplementary note on linyphiid spiders of Japan. *Journal of Biology, Osaka City University* (Series D) 15: 23-30.

Pickard-Cambridge O. 1913. On new and rare British arachnids noted and observed in 1912. *Proceedings of the Dorset Natural History and Antiquarian Field Club* 34: 107-136.

Saaristo M.I., Tanasevitch A.V. 1996. Redelimitation of the subfamily Micronetinae Hull, 1920 and the genus *Lepthyphantes* Menge, 1866 with descriptions of some new genera (Aranei, Linyphiidae). *Berichte des Natur-wissenschaftlich-Medizinischen Vereins in Innsbruck* 83: 163-186.

Simon E. 1886. Arachnides recueillis par M. A. Pavie (sous chef du service des postes au Cambodge) dans le royaume de Siam, au Cambodge et en Cochinchine. *Actes de la Société Linnéenne de Bordeaux* 40: 137-166.

Simon E. 1913. Biospeologica, XXX. Araneae et Opiliones. Quatrième série. *Archives de Zoologie Expérimentale et Générale* 52(2): 359-386.

Tanasevitch A.V. 1987. The spider genus *Lepthyphantes* Menge 1866 in Nepal (Arachnida: Araneae: Linyphiidae). *Courier Forschungsinstitut Senckenberg* 93: 43-64.

Tanasevitch A.V. 1998a. *Gorbothorax* n. gen., a new linyphiid spider genus from the Nepal Himalayas (Arachnida, Araneae, Linyphiidae). *Bonner Zoologische Beiträge* 47: 421-428.

Tanasevitch A.V. 1998b. New *Oedothorax* Bertkau, 1883, from Nepal (Arachnida, Araneae, Linyphiidae). *Bonner Zoologische Beiträge* 47: 429-441.

Tanasevitch A.V. 2009. The linyphiid spiders of Iran (Arachnida, Araneae, Linyphiidae). *Revue suisse de Zoologie* 116: 379-420.

Tanasevitch A.V. 2011. Linyphiid spiders (Araneae, Linyphiidae) from Pakistan and India. *Revue suisse de Zoologie* 118: 561-598.

Tanasevitch A.V. 2014a. New species and records of linyphiid spiders from Laos (Araneae, Linyphiidae). *Zootaxa* 3841(1): 67-89.

Tanasevitch A.V. 2014b. On the linyphiid spiders from Thailand and West Malaysia (Arachnida: Aranei: Linyphiidae). *Arthropoda Selecta* 23(4): 393-414.

Tanasevitch A.V. 2017. New species and new records of linyphiid spiders from the Indo-Malayan Region (Araneae, Linyphiidae). *Zootaxa* 4227(3): 325-346.

Tanasevitch A.V. 2018. Two new species of the family Linyphiidae from the Himalayas (Arachnida: Aranei). *Arthropoda Selecta* 27(3): 239-243.

Tanasevitch A.V. 2019a. A new erigonine genus from the Nepal Himalayas (Araneae, Linyphiidae). *Turkish Journal of Zoology* 43(2): 229-232.

Tanasevitch A.V. 2019b. On the erigonine genera *Hubertella* Platnick, 1989 and *Oia* Wunderlich, 1973 in the Himalayas (Aranei: Linyphiidae), with descriptions of two new species. *Arthropoda Selecta* 28(1): 147-151.

Tanasevitch A.V. 2019c. Two new *Tapinocyba* Simon, 1884 from the highlands of Nepal (Aranei: Linyphiidae). *Arthropoda Selecta* 28(2): 305-308.

Tanasevitch A.V. 2019d. A new genus and new records of linyphiid spiders from the Oriental Region (Aranei: Linyphiidae). *Arthropoda Selecta* 28(3): 448-452.

Tanasevitch A.V. 2019e. On the spider genus *Racata* Millidge, 1995, with the description of three new species (Araneae, Linyphiidae). *Revue suisse de Zoologie* 126(1): 53-59.

Tanasevitch A.V. 2020a. The genus *Oedothorax* Bertkau, 1883 in the Himalayas, with descriptions of four new species from Nepal (Aranei: Linyphiidae). *Arthropoda Selecta* 29(2): 283-291.

Tanasevitch A.V. 2020b. On linyphiid spiders from Java, Indonesia, with the description of three new genera and four new species (Araneae: Linyphiidae). *Revue suisse de Zoologie* 127(1): 63-74.

Tanasevitch A.V. 2021. Two new erigonine spiders from Nepal (Aranei, Linyphiidae). *Arthropoda Selecta* 30(1): 125-129.

Tanasevitch A.V., Saaristo M.I. 2006. Reassessment of the Nepalese species of the genus *Lepthyphantes* Menge s. l. with descriptions of new Micronetinae genera and species (Araneae, Linyphiidae, Micronetinae). *Senckenbergiana Biologica* 86: 11-38.

Thaler K. 1987. Über einige Linyphiidae aus Kashmir (Arachnida: Araneae). *Courier Forschungsinstitut Senckenberg* 93: 33-42.

Tu L.H., Li S.Q. 2004. A preliminary study of erigonine spiders (Linyphiidae: Erigoninae) from Vietnam. *The Raffles Bulletin of Zoology* 52: 419-33.

Wiehle H. 1960. Der Embolus des männlichen Spinnentasters.

Verhandlungen der Deutschen Zoologischen Gesellschaft 1960: 457-480.

World Spider Catalog 2020. World Spider Catalog, version 21.5. Natural History Museum Bern. Available at http://wsc.nmbe.ch (accessed in November 2020).

Wunderlich J. 1972. Zur Kenntnis der Gattung *Walckenaeria* Blackwall 1833 unter besonderer Berücksichtigung der europäischen Subgenera und Arten (Arachnida: Araneae: Linyphiidae). *Zoologische Beiträge (N.F.)* 18: 371-427.

Wunderlich J. 1973. Linyphiidae aus Nepal. Die neuen Gattungen *Heterolinyphia*, *Martensinus*, *Oia* und *Paragongylidiellum* (Arachnida: Araneae). *Senckenbergiana Biologica* 54(4/6): 429-443.

Wunderlich J. 1974. Linyphiidae aus Nepal, II. Die Gattung *Oedothorax* Bertkau 1883 (Arachnida: Araneae). *Senckenbergiana Biologica* 55: 169-188.

Wunderlich J. 1977. Zur Kenntnis der *Lepthyphantes nebulosus*-Gruppe (Arachnida: Araneida: Linyphiidae). *Senckenbergiana Biologica* 58: 57-61.

Wunderlich J. 1979. Linyphiidae aus Nepal, III. Die Gattungen *Caviphantes* Oi 1960 und *Lessertiella* Dumitrescu & Miller 1962 (Arachnida: Araneae). *Senckenbergiana Biologica* 60(1-2): 85-89.

Wunderlich J. 1983. Linyphiidae aus Nepal, IV. Bisher unbekannte und für Nepal neue Arten (Arachnida: Araneae). *Senckenbergiana Biologica* 63(3/4): 219-248.

Zhao Q.Y., Li S.Q. 2014. A survey of linyphiid spiders from Xishuangbanna, Yunnan Province, China (Araneae, Linyphiidae). *ZooKeys* 460: 1-181.

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Is *Acerentomon italicum* Nosek, 1969 (Protura: Acerentomidae) a species complex?

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Abstract: *Acerentomon italicum* Nosek, 1969 is the most abundant Protura species in Italy. Two groups of populations characterized by the different position of a pore on tergite VII were analyzed. Specimens from Austria and from the Italian provinces of Brescia and Bolzano (Lombardy and Alto Adige, respectively) possess a postero-sub-medial pore (*psm*); in specimens from Trento (Trentino), Veneto, Friuli-Venezia Giulia and Liguria the pore is in an antero-sub-lateral (*asl*) position. An integrative approach was applied to assess other characters distinguishing these populations. The lengths of body, head, foretarsus, claw of anterior leg, foretarsal sensilla *a* and *b* were measured; in addition some ratios were calculated: TR (length of foretarsus/length of its claw), BS (distance of sensillum *t1* from base of foretarsus/distance of *t1* from foretarsus tip), length of *a*/foretarsus length, length of *b*/foretarsus length and length of *a*/length of *b*. A geometric morphometric analysis was performed on the position of setae on tergite VII, selecting as landmarks the bases of setae *A1*, *A2*, *A3*, *P1*, *P1a*, *P2*, *P2a* and *P3*. Nucleotide sequences COI-5P and 28S-D2-D3 of both groups were compared. Significant differences in the foretarsus and anterior claw length, in the arrangement of setae on tergite VII and in the barcode sequences COI-5P between the "*psm* and *asl* populations" are shown to exist. Based on the results obtained, the two groups are different, but there is not enough support to differentiate them at the species level.

Keywords: DNA barcoding - geometric morphometrics - genetic distance - integrative systematics - morphometry - porotaxy.

INTRODUCTION

Acerentomon italicum Nosek, 1969 is the most abundant Protura species in Italy (Galli *et al.*, 2016) and it is widespread in Switzerland, Austria, Corsica and Slovenia. A recent redescription of the species (Galli *et al.*, 2016) highlighted the difference between two groups of populations with regards to the porotaxy of tergite VII. Porotaxy was used as a diagnostic character to distinguish Protura species for about thirty years (e.g. Szeptycki, 1991), and it was already pointed out that the position of a single pore can differ between two closely related species. A good example is the difference in porotaxy between *Gracilentulus gracilis* Berlese, 1908b and *G. europaeus* Szeptycki, 1993 highlighted by Szeptycki (1993). Throughout most of its range (including the type area) specimens of *A. italicum* possess a single antero-sub-lateral (*asl*) pore close to the base of seta *A3*. Specimens from Switzerland, Austria, Lombardy, Friuli-Venezia Giulia and Slovenia, however, have a postero-sub-medial (*psm*) pore close to the base of seta *P1* instead. The latter is the typical position of such a pore in the Acerentomidae (Shrubovych, 2014). The remaining porotaxy and chaetotaxy of these two groups is largely identical, with a certain level of variability that characterizes all species. Moreover, DNA barcoding showed a remarkable distance between a group of three Ligurian populations (*asl*) and one from Austria (*psm*) (Galli *et al.*, 2016). These results prompted us to look for further characteristics that can distinguish the two "groups of populations" (from here on indicated as *asl* and *psm* populations). In this paper the results of an integrative study, based on genetic data, specific morphometric analysis and through a geometric morphometric analysis,

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are shown. Geometric morphometrics, in particular, is a groundbreaking approach in Protura that deserves more attention in the future.

MATERIAL & METHODS

Morphometry

Abbreviations of depositories: MHNG = Natural History Museum of Geneva, Switzerland; UniGe = Genoa University collection, Italy; ISEAPol = Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Poland.

Material examined: MHNG; 2 ♀; Austria, Gaisberg. – MHNG; 1 ♂, 1 ♀; Austria, St Pankraz. – MHNG; 7 ♂, 7 ♀; Austria, Plabutsh. – ISEAPol; 1 ♀; Austria, Leopoldsberg, Vienna. – UniGe; 5 ♂, 13 ♀; Italy, Lombardy, Brescia Province, Polaveno. – MHNG; 1 ♂; Italy, Trentino-Alto Adige, Bolzano Province, Brunico. – MHNG; 2 ♀; Italy, Trentino-Alto Adige, Trento Province, Levico Terme. – MHNG; 5 ♂, 4 ♀; Italy, Veneto, Belluno Province, Ponte nelle Alpi. – MHNG; 3 ♂, 2 ♀; Italy, Friuli-Venezia Giulia, Udine Province, Paluzza. – MHNG; 1 ♂; Friuli-Venezia Giulia, Udine Province, surroundings of Tolmezzo. – UniGe; 1 ♂, 5 ♀; Italy, Liguria, Savona Province, Bergeggi. – UniGe; 5 ♂, 5 ♀; Italy, Liguria, Genoa Province, Genoa Quinto.

For a map of the localities listed above, see Fig. 1.

Measurements: The presence of a pore in the *asl* or *psm* position was detected (Fig. 2). When possible, the following measurements (and ratios of two measurements) of each specimen were taken: body, head, foretarsus and claw of anterior leg lengths (in the following simply referred to as tarsus and claw, as commonly used in the literature on Protura); TR (length of tarsus/length of claw) and BS (distance of sensillum *t1* from base of tarsus/distance of *t1* from tarsus tip) ratios (see Nosek, 1973); foretarsal sensilla *a* and *b* lengths; ratio of length of *a*/tarsus length, ratio of length of *b*/tarsus length and ratio of length of *a*/length of *b*. Measurements were taken with the aid of an interference contrast microscope (Leica DM LB2), a Leica DFC 295 camera and a Leica Application Suite Vers. 3.8. Data were archived separately based on pore position (*asl* or *psm* populations) and sex of specimens.

Statistical analyses: For each character measured outliers were removed before the application of the following analyses. On the measurements taken One-way ANOVA and Mann-Whitney pairwise test (adopting a Bonferroni correction of p-values) were performed to see differences between sexes within the same "population" and between values recorded in *psm* and *asl* specimens within each sex. For statistically significant variables a linear correlation with the geographic coordinates of sampling localities was performed to verify any latitudinal or longitudinal trend. Analyses were made using the software "PAST" (Paleontological Statistics) version 4.02 (Hammer *et al.*, 2001).

Geometric morphometrics

Landmarks placement: The Leica system described above was also used to take photos of tergite VII of 53 specimens belonging to both populations (*asl*: 15 males and 18 females - *psm*: 9 males and 11 females). Specimens were selected in which on one side of tergite VII the landmarks mentioned below were coplanar, resulting in all being in focus at the same time. Based on these photos the coordinates of defined sets of landmarks were acquired for each specimen. The sets of coordinates (called landmark configurations) contain the information related to shape and size, orientation and location of setae on tergite VII. In particular, eight type I bidimensional landmarks (Bookstein, 1997) were defined: the bases of setae *A1*, *A2*, *A3*, *P1*, *P1a*, *P2*, *P2a* and *P3* (Fig. 2). The TPS software was used for image storing and landmarks placing (TPSutil, version 1.74, see Rohlf, 2017a and TpsDig, version 2.30, see Rohlf, 2017b).

Further analyses were performed using the "geomorph" package (Adams *et al.*, 2020), written in the "R" scientific computing language (R Core Team, 2020). Landmarks previously digitized with TPS Dig were imported into the R environment using the "readland.tps()" function.

Generalized procrustes analysis: The first step of any geometric morphometric analysis is to perform a Procrustes superimposition of the raw coordinate data (for a general overview of geometric morphometrics see Adams *et al.*, 2013). A Generalized Procrustes Analysis (GPA, see Rohlf & Slice, 1990) translates all specimens to the origin, scales them to unit-centroid size, and optimally rotates them (using a least-squares criterion) until the coordinates of corresponding landmarks align as closely as possible. The resulting aligned Procrustes coordinates represent the shape of each specimen, and are found in a curved space related to Kendall's shape space (Kendall, 1984). To perform this analysis the "gpagen()" function was used. GPA allows to extract the shape information from all landmark configurations

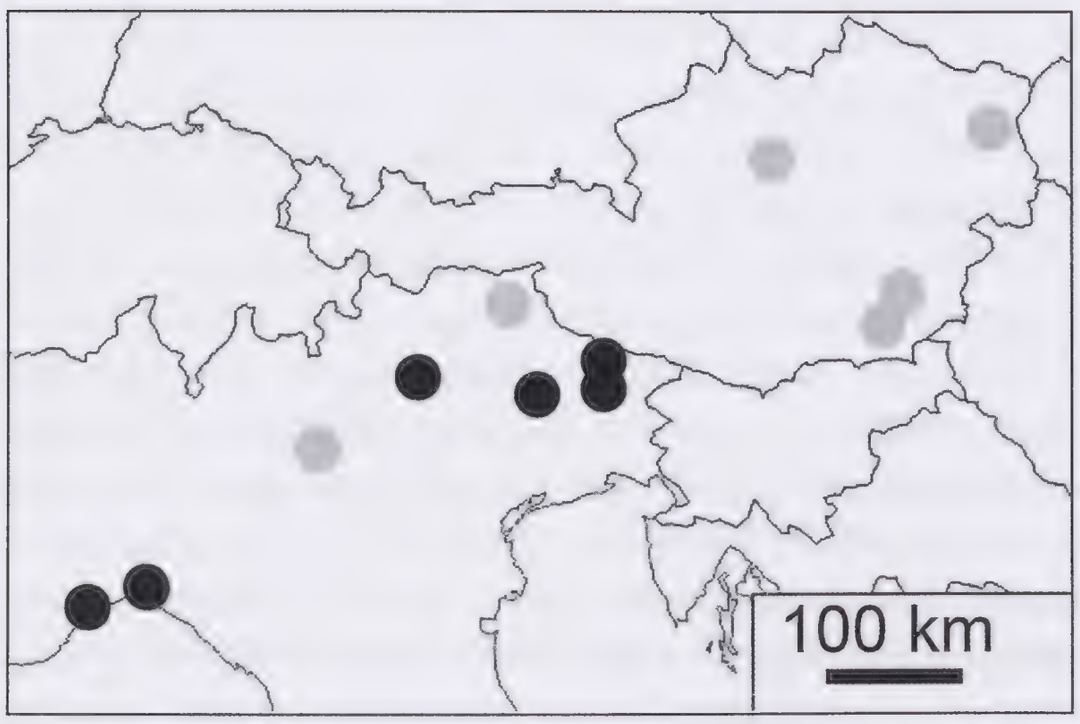

Fig. 1. Geographical distribution of examined populations of *Acerentomon italicum* (grey = with *psm* pore; black = with *asl* pore).

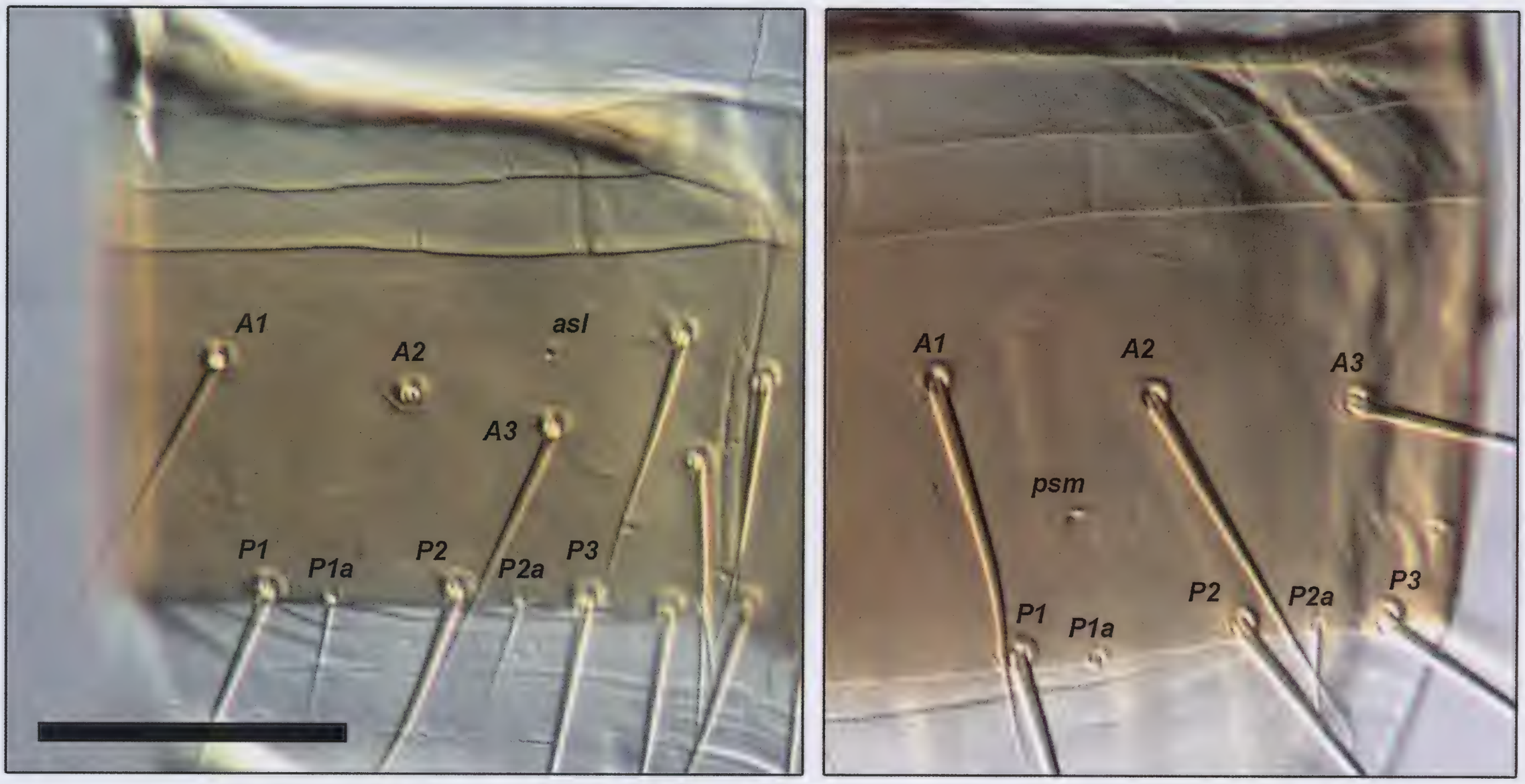

Fig. 2. *Acerentomon italicum*, tergite VII: landmarks used for geometric morphometric analysis of *asl* (left) and *psm* (right) populations. Scale bar = 50 µm.

by removing the parameters of non-shape variation (i.e. differences in size, location and orientation). Information carried by location is removed by shifting the landmarks configurations until they share the same origin in a common coordinate system (Theska *et al.*, 2020) where each landmark is represented by shape variables called "Procrustes coordinates". A data-cleaning process using the "plotOutliers()" function led to remove from the resulting analyses four specimens that proved to be outliers: one male and two females belonging to the *psm* group, and one female belonging to the *asl* group. Aligned coordinates of the remaining 49 specimens were represented using the "plotAllSpecimens()" function that creates a plot of the landmark coordinates for all specimens. This is useful for examining patterns of shape variation after GPA. Selecting "mean=TRUE", the mean shape was calculated and added to the plot (Fig. 3). Together with procrustened coordinates, the consensus and the centroid size were retrieved. Centroid size (CS) is the most common and explicit measure of size in geometric morphometrics. It is computed as the square root of the sum of the squared distances of all landmarks from their centroid (Rohlf & Slice, 1990; Goodall, 1991; Dryden & Mardia, 1998).

Principal Component Analysis: The Principal Component Analysis (PCA) is probably the most common method used to visualize the general patterns of morphological variation in multidimensional data (in this case the covariance matrix of the procrustened coordinates of landmarks). By definition, the first principal component (PC1) retains the maximum possible variance (Jolliffe, 2002; Abdi & Williams, 2010). The cumulative variance explained by each PC was examined and the relative screeplot was used to select the number of PCs for further analyses.

The Wilcoxon-Mann-Whitney test was performed to highlight differences between groups. Extreme shape variation along the PCs was explored using the "plotRefToTarget()" function. To assess the reliability of the PCA results, a cross validated (using leave-one-out jacknife procedure) linear discriminant analysis (LDA) (MASS package, Ripley *et al.*, 2013) was run on extracted PCs. Discrimination was performed separately between populations and sexes.

Thus scores were considered as the projection of the centered data in the linear space defined by the eigenvectors (Jolliffe, 2002). Therefore they were analyzed to understand shape variations between groups into a dimensionally reduced space. Nevertheless the loadings were used to assess the weight of each variable in the description of the shape variation in every PC using the "fviz_contrib()" function from the "factoextra" package (Kassambara & Mundt, 2017).

Covariation method: To infer differences in shape according to factors or continuous variables, the "procD.lm()" function was used. It performs Procrustes ANOVA with permutation procedures to verify statistical hypotheses describing patterns of shape variation and covariation for a set of Procrustes-aligned coordinates. The mean shape variation among factors (populations and sexes) was tested by means of a Goodall's F test (Goodall, 1991). A second model (multivariate regression) was

used to describe shape variation according to size. Since size in geometric morphometrics is represented by centroid size, a simple multivariate regression, where shape represents the response variable and the centroid size represents the independent variable, was fitted to the data. Lastly a multivariate analysis of variance (single factor MANCOVA) was used to test changes in shape between groups, while accounting for shape varying with size.

Genetic distances

Nucleotide sequences COI-5P and 28s-D2-D3 available on the Barcode of Life Data systems (BOLD - https://www.boldsystems.org/) for *Acerentomon* species belonging to *doderoi*-group (sensu Nosek, 1973) were analyzed: *A. italicum*, *A. christiani* Shrubovych & Resh in Shrubovych *et al.*, 2016, *A. maius* Berlese, 1908b (Tables 1-2). Alignment of sequences was performed using "MUSCLE", as implemented in Mega v. 7.0.20 (Kumar *et al.*, 2016). The genetic distances based on Kimura 2-parameter (Kimura, 1980) were calculated within groups and between groups using the appropriate menu on Mega v. 7.0.20. In order to evaluate their taxonomic significance, the specimens belonging to the *A. italicum psm* population were considered as part of a separate Molecular Operational Taxonomic Unit (MOTU).

RESULTS

Morphometry

Values of the variables measured in *asl* and *psm*

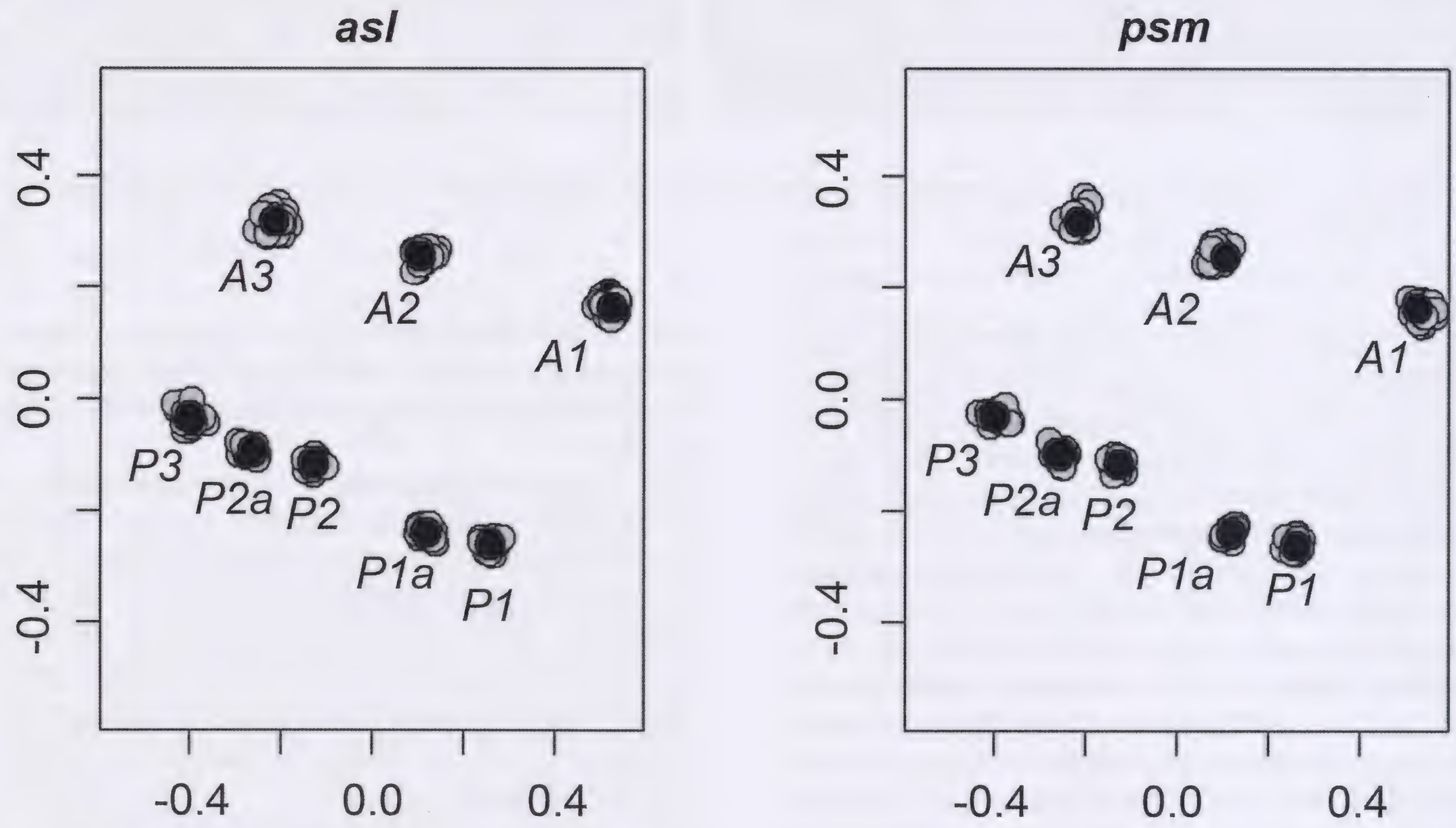

Fig. 3. Procrustes coordinates: landmarks configuration for the examined populations (*asl*, left, *psm* right). Black dots represent the mean shape (consensus).

Table 1. Accession numbers at Barcode of Life Data systems (BOLD) for specimens belonging to the *Acerentomon doderoi*-group whose nucleotide sequences COI-5P were used in this work. *Acerentomon italicum* specimens without notes belong to Italian populations with an *asl* pore.

BOLD Nr|Species|Sequence analysed	NOTES
PROAT001-12|Acerentomon_maius|COI-5P	
PROAT005-12|Acerentomon_maius|COI-5P	
PROAT006-12|Acerentomon_maius|COI-5P	
PROAT015-12|Acerentomon_maius|COI-5P	
PROAT016-12|Acerentomon_maius|COI-5P	
PROAT017-12|Acerentomon_maius|COI-5P	
PROAT018-12|Acerentomon_maius|COI-5P	
PROAT019-12|Acerentomon_maius|COI-5P	

Table 1 (continued)

BOLD Nr|Species|Sequence analysed	NOTES
PROAT020-12|Acerentomon_maius|COI-5P	
PROAT024-12|Acerentomon_maius|COI-5P	
PROAT025-12|Acerentomon_sp._gr_doderoi|COI-5P	*Acerentomon christiani*, see Shrubovych *et al.*, 2016
PROAT026-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT027-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT029-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT030-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT031-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT032-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT033-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT034-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT035-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT036-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT037-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT038-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT039-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT040-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT041-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT042-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT054-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT055-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT063-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT064-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT065-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT066-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT069-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT071-12|Acerentomon_sp._gr_doderoi|COI-5P	
PROAT052-12|Acerentomon_italicum|COI-5P	From Leopoldsberg (AUT), with *psm* pore
PROIT001-15|Acerentomon_italicum|COI-5P	
PROIT002-15|Acerentomon_italicum|COI-5P	
PROIT003-15|Acerentomon_italicum|COI-5P	
PROIT004-15|Acerentomon_italicum|COI-5P	
PROIT005-15|Acerentomon_italicum|COI-5P	
PROIT006-15|Acerentomon_italicum|COI-5P	
PROIT007-15|Acerentomon_italicum|COI-5P	
PROIT008-15|Acerentomon_italicum|COI-5P	
PROIT009-15|Acerentomon_italicum|COI-5P	
PROIT010-15|Acerentomon_italicum|COI-5P	
PROIT011-15|Acerentomon_italicum|COI-5P	
PROIT012-15|Acerentomon_italicum|COI-5P	
PROIT013-15|Acerentomon_italicum|COI-5P	
PROIT014-15|Acerentomon_italicum|COI-5P	
PROIT015-15|Acerentomon_italicum|COI-5P	
PROIT016-15|Acerentomon_italicum|COI-5P	
PROIT017-15|Acerentomon_italicum|COI-5P	
PROIT018-15|Acerentomon_italicum|COI-5P	
PROIT019-15|Acerentomon_italicum|COI-5P	
PROIT020-15|Acerentomon_italicum|COI-5P	
PROIT021-15|Acerentomon_italicum|COI-5P	

Table 2. Accession numbers at Barcode of Life Data systems (BOLD) for specimens belonging to the *Acerentomon doderoi*-group whose nucleotide sequences 28S-D2-D3 were used in this work. *Acerentomon italicum* specimens without notes belong to Italian populations with an *asl* pore.

BOLD Nr|Species|Sequence analysed	**NOTES**
PROAT001-12|Acerentomon_maius|28S-D2-D3	
PROAT006-12|Acerentomon_maius|28S-D2-D3	
PROAT020-12|Acerentomon_maius|28S-D2-D3	
PROAT005-12|Acerentomon_maius|28S-D2-D3	
PROAT015-12|Acerentomon_maius|28S-D2-D3	
PROAT016-12|Acerentomon_maius|28S-D2-D3	
PROAT018-12|Acerentomon_maius|28S-D2-D3	
PROAT024-12|Acerentomon_maius|28S-D2-D3	
PROAT096-13|Acerentomon_maius|28S-D2-D3	
PROAT017-12|Acerentomon_maius|28S-D2-D3	
PROAT019-12|Acerentomon_maius|28S-D2-D3	
PROAT027-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	*Acerentomon christiani*, see Shrubovych *et al.*, 2016
PROAT030-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT033-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT037-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT040-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT042-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT063-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT031-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT032-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT034-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT035-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT069-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT071-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT100-13|Acerentomon_sp._gr._doderoi|28S-D2-D3	
PROAT026-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT036-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT041-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT054-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT055-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT064-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT065-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT066-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT038-12|Acerentomon_sp._gr_doderoi|28S-D2-D3	
PROAT092-13|Acerentomon_sp.|28S-D2-D3	*A. italicum* Austria, with *psm* pore
PROAT091-13|Acerentomon_cf._italicum|28S-D2-D3	*A. italicum* Austria, with *psm* pore
PROAT052-12|Acerentomon_italicum|28S-D2-D3	*A. italicum* Austria, with *psm* pore
PROIT003-15|Acerentomon_italicum|28S-D2-D3	
PROIT007-15|Acerentomon_italicum|28S-D2-D3	
PROIT009-15|Acerentomon_italicum|28S-D2-D3	
PROIT011-15|Acerentomon_italicum|28S-D2-D3	
PROIT014-15|Acerentomon_italicum|28S-D2-D3	
PROIT016-15|Acerentomon_italicum|28S-D2-D3	
PROIT020-15|Acerentomon_italicum|28S-D2-D3	
PROIT004-15|Acerentomon_italicum|28S-D2-D3	
PROIT006-15|Acerentomon_italicum|28S-D2-D3	

Table 2 (continued)

BOLD Nr|Species|Sequence analysed	NOTES
PROIT010-15|Acerentomon_italicum|28S-D2-D3	
PROIT015-15|Acerentomon_italicum|28S-D2-D3	
PROIT017-15|Acerentomon_italicum|28S-D2-D3	
PROIT019-15|Acerentomon_italicum|28S-D2-D3	
PROIT001-15|Acerentomon_italicum|28S-D2-D3	
PROIT002-15|Acerentomon_italicum|28S-D2-D3	
PROIT008-15|Acerentomon_italicum|28S-D2-D3	
PROIT012-15|Acerentomon_italicum|28S-D2-D3	
PROIT013-15|Acerentomon_italicum|28S-D2-D3	
PROIT018-15|Acerentomon_italicum|28S-D2-D3	
PROIT021-15|Acerentomon_italicum|28S-D2-D3	

Table 3. *Acerentomon italicum*: morphometry of *asl* and *psm* populations. Mean values ± standard deviations; lengths in µm.

	psm		***asl***	
	Males (n = 14)	**Females (n = 24)**	**Males (n = 15)**	**Females (n = 18)**
Body length	1600 ± 142	1696 ± 190	1533 ± 91	1679 ± 76
Head length	214 ± 15	224 ± 11	203 ± 12	208 ± 15
Tarsus length	114 ± 7	118 ± 4	104 ± 4	109 ± 5
Claw length	41 ± 1	44 ± 3	40 ± 2	40 ± 2
TR	2.53 ± 0.13	2.61 ± 0.14	2.48 ± 0.14	2.58 ± 0.11
BS	0.57 ± 0.04	0.56 ± 0.06	0.54 ± 0.04	0.54 ± 0.03
Sensillum *a* length	30 ± 2	31 ± 2	29 ± 2	30 ± 2
Sensillum *b* length	19 ± 2	20 ± 2	18 ± 1	19 ± 2
Sensillum *a*/tarsus	0.25 ± 0.01	0.25 ± 0.02	0.27 ± 0.02	0.27 ± 0.02
Sensillum *b*/tarsus	0.16 ± 0.01	0.16 ± 0.02	0.17 ± 0.01	0.16 ± 0.01
Sensillum *a*/Sensillum *b*	1.49 ± 0.15	1.52 ± 0.16	1.53 ± 0.11	1.58 ± 0.15

populations are shown in Table 3. The One-way ANOVA and Mann-Whitney pairwise test (adopting a Bonferroni correction of p-values) showed only two variables with statistically significant differences between *psm* and *asl* populations: tarsus length ($F = 23.22$; $p << 0.001$) and claw length ($F = 12.18$; $p = 0.0025$). Both characters have significantly larger values in *psm* than *asl* populations (Table 4, Fig. 4). For none of the characters it was possible to outline a latitudinal or longitudinal trend. Larger sizes of females than males within the same group were not statistically significant.

Geometric morphometrics

The first four components of PCA accounted for more than 73% of the total shape variation (Table 5). Also the screeplot inspection (Fig. 5) confirmed the same number of principal components as a reliable measure. The scoreplot based on the first two PCs shows that the two populations were quite different in shape (Fig. 6).

Table 4. Mann-Whitney pairwise test (adopting Bonferroni correction of p-values). Output for tarsus length and claw length.

Tarsus length				
	***psm* M**	***psm* F**	***asl* M**	***asl* F**
***psm* M**		1	< 0.001	0.044
***psm* F**	1		<< 0.001	<< 0.001
***asl* M**	< 0.001	<< 0.001		0.1884
***asl* F**	0.044	<< 0.001	0.1884	
Claw length				
	***psm* M**	***psm* F**	***asl* M**	***asl* F**
***psm* M**		0.85	0.017	0.005
***psm* F**	0.85		0.004	< 0.001
***asl* M**	0.017	0.004		1
***asl* F**	0.005	< 0.001	1	

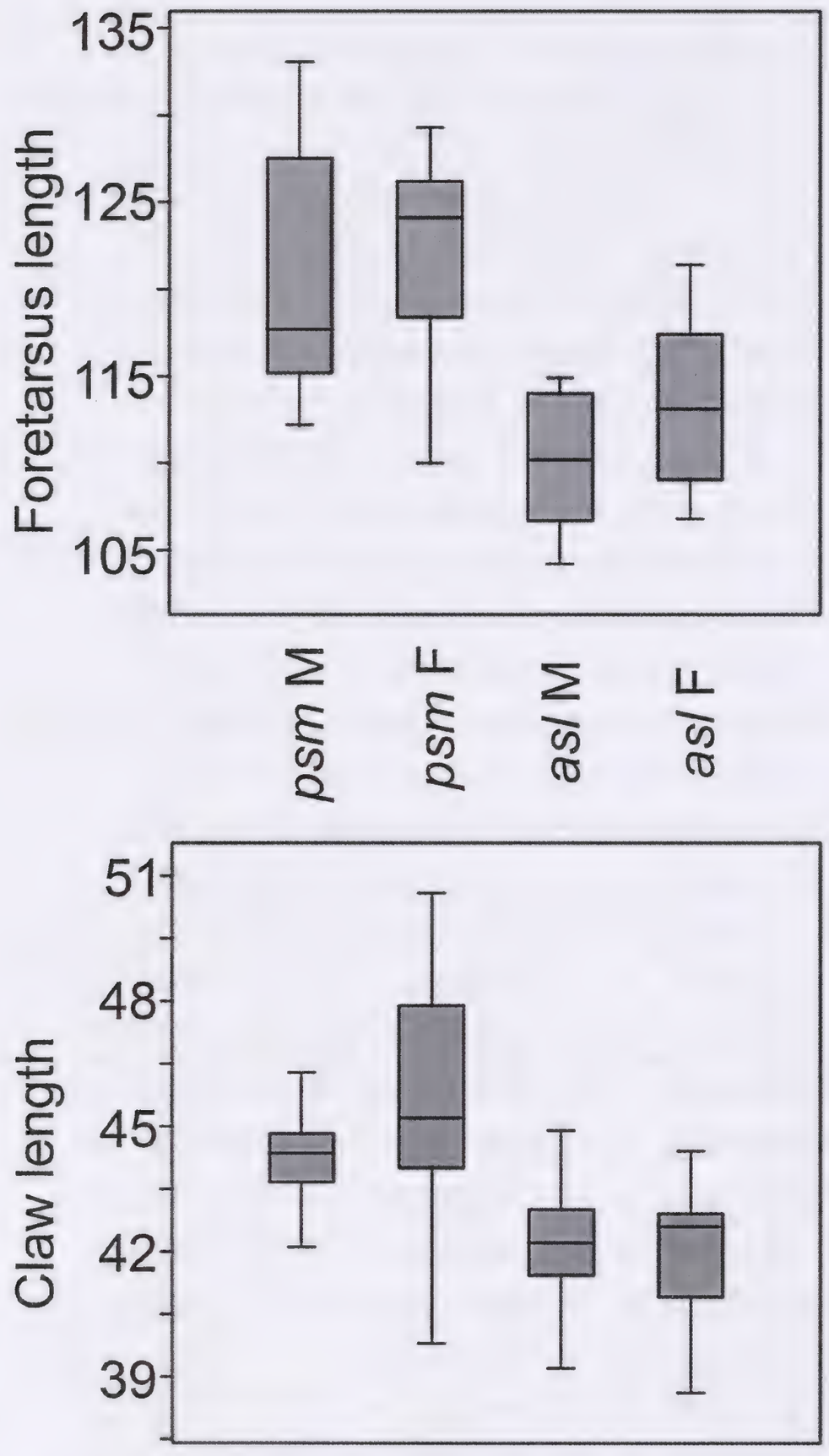

Fig. 4. Boxplot of tarsus and claw length measurements in both sexes of *psm* and *asl* populations of *Acerentomon italicum*.

Only for the first two PCs Wilcoxon-Mann-Whitney tests on differences between groups retrieved significant differences (PC1: U = 474, p = 5.83E-06; PC2: U = 360, p = 6.57E-02). When sexes were compared, no clear distinctions arose from between-group inference. Since only PC1 and PC2 accounted for shape variation, extreme shape deformations along these axes were plotted as a thin-plate spline deformation grid (Fig. 7). More than 40% of variation in PC1 was due to the horizontal coordinate of seta *A2* (*A2x*), while PC2 shows a more even situation where *P3* and *A3* accounted for most of the variation (Fig. 8).

A linear discriminant analysis performed between populations confirmed the reliability of PCA, showing that the first four PCs have an overall classification accuracy of 83.7% (41 specimens correctly classified from a total of 49, Table 6), while discrimination between males and females did not provide meaningful results (51% overall accuracy).

The Goodall test retrieved significant differences in setae

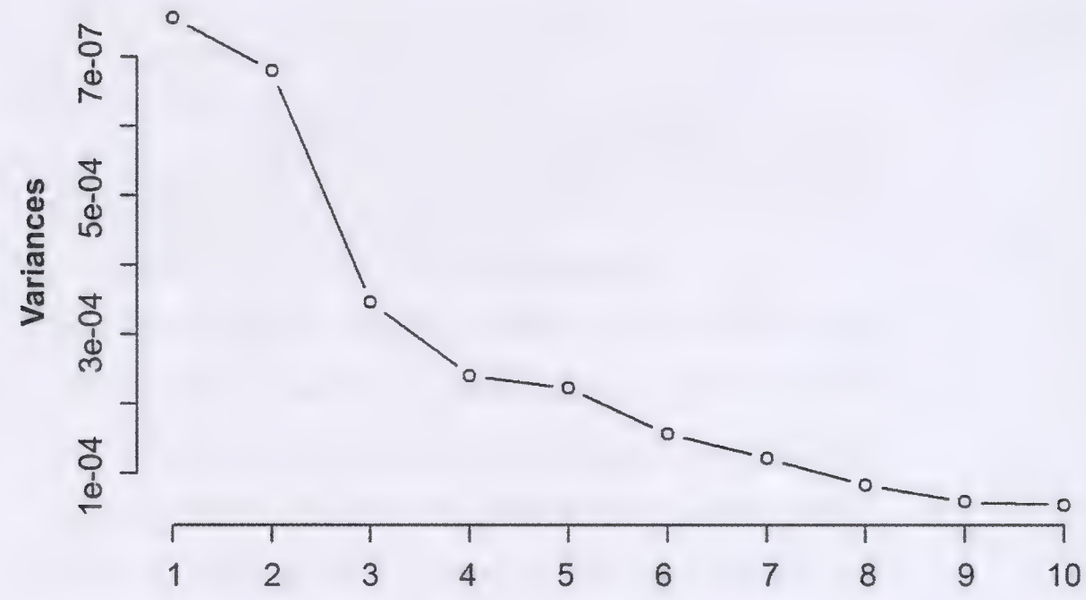

Fig. 5. Screeplot of PCA run on procrustened coordinates.

Table 5. Results of principal components analysis (PCA). For each PC the amount of explained variance is reported together with the cumulative proportions (both in %).

	Variance	Cumulative
PC01	27.24	27.24
PC02	24.52	51.76
PC03	12.47	64.23
PC04	8.67	72.90
PC05	8.02	80.91
PC06	5.67	86.58
PC07	4.39	90.97
PC08	2.99	93.95
PC09	2.14	96.09
PC10	1.95	98.04
PC11	1.32	99.36
PC12	0.64	100.00
PC13	0.00	100.00
PC14	0.00	100.00
PC15	0.00	100.00
PC16	0.00	100.00

arrangement only between populations (F = 7.2242, p = 1e-04 with 1 and 48 df) but not between sexes (F = 0.7429, p = 6.17E-01 with 1 and 48 df). Despite centroid size showing a strong group structure both between populations (W = 35, p-value = 2.36E-08) and sexes (W = 412, p-value = 2.32E-02), multivariate regression highlighted a barely significant amount of covariation between shape and size (F = 1.91; p = 0.05 with 1 and 48 df).

Genetic distances

Values of Kimura 2-parameter within-group and between-group genetic distances (Kimura, 1980) calculated on the basis of the nucleotide sequences COI-5P and 28s-D2-D3 available at BOLD for *Acerentomon* species belonging to the *doderoi*-group are shown in Tables 7-8. With regard to the barcode sequence COI-5P, the distance of 0.292 between the only available specimen

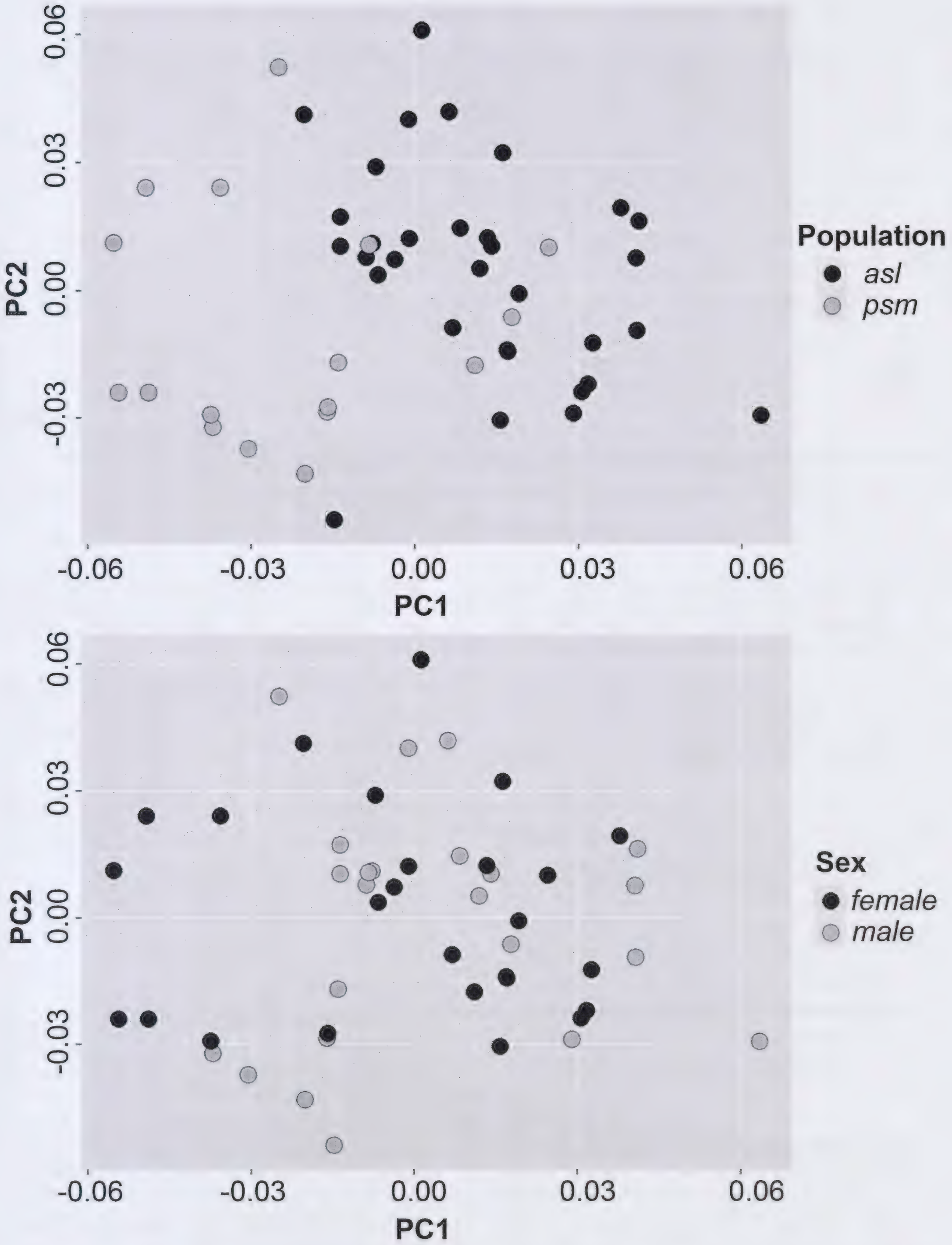

Fig. 6. Scoreplots of the principal component analysis performed on 49 *A. italicum* specimens and 8 landmarks along the first two principal axes explaining 27.24% (PC1) and 24.17% (PC2) of the shape variation.

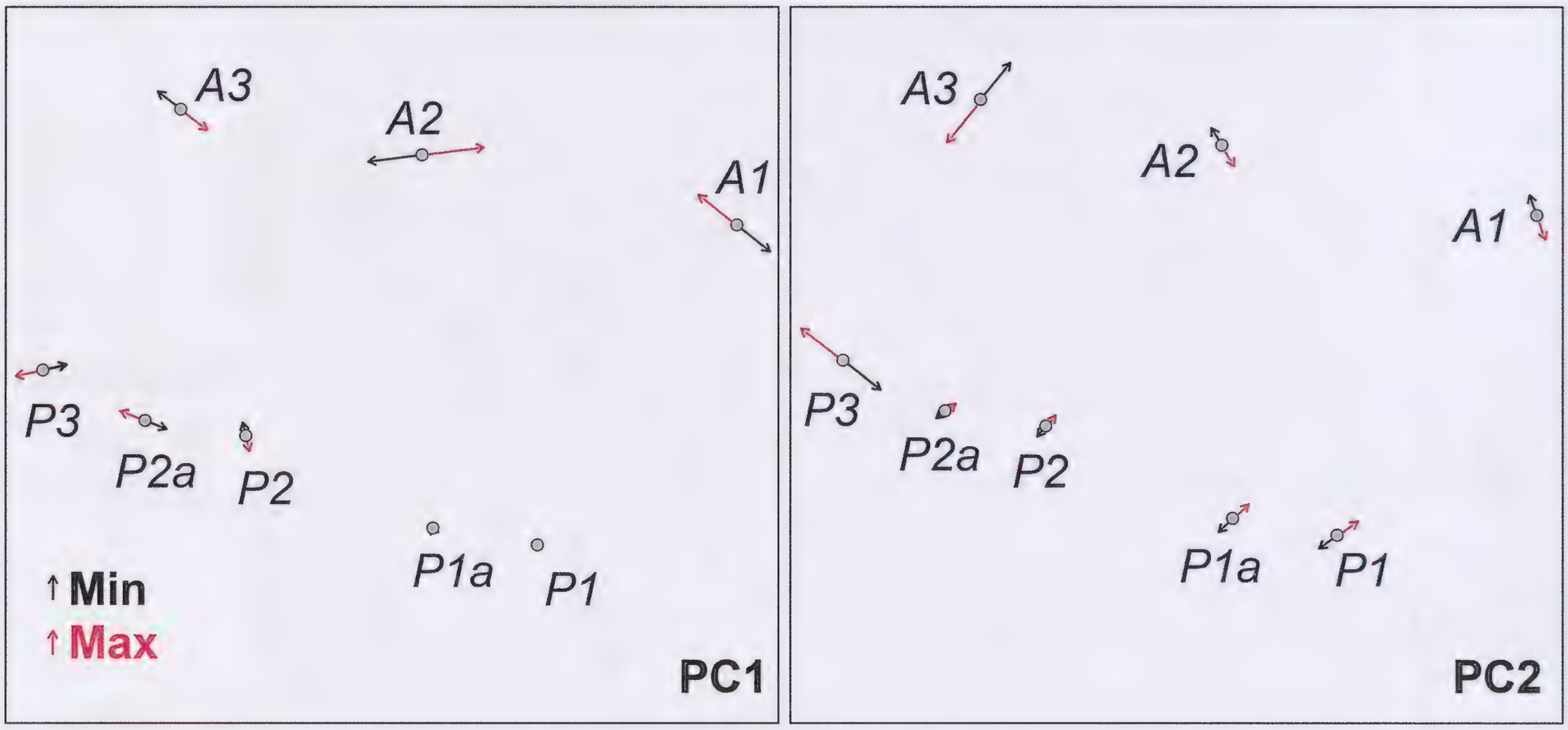

Fig. 7. Extreme shape deformation for PC1 and PC2 maximum and minimum values. Arrows show deformations from mean shape (consensus).

Table 6. Confusion matrix obtained performing LDA on first four PCs. The numbers of specimens correctly identified as belonging to *asl* (top left) and *psm* (down right) populations are given.

	asl	***psm***
asl	30	2
psm	6	11

Table 7. Genetic distances based on Kimura 2-parameter within *Acerentomon* species belonging to the *doderoi*-group (comparing COI-5P and 28S-D2-D3 sequences).

	COI-5P	28S-D2-D3
A. maius	0.002	0.001
A. christiani	0.001	0
A. italicum (psm)	-	0
A. italicum (asl)	0.014	0.075

Table 8. Genetic distances based on Kimura 2-parameter between *Acerentomon* species belonging to the *doderoi*-group (comparing COI-5P and 28S-D2-D3 sequences).

	A. maius	*A. christiani*	*A. italicum (asl)*
COI-5P			
A. christiani	0.288		
A. italicum (asl)	0.362	0.347	
A. italicum (psm)	0.324	0.305	0.292
28S-D2-D3			
A. christiani	0.158		
A. italicum (asl)	0.168	0.218	
A. italicum (psm)	0.139	0.182	0.077

of *A. italicum* belonging to the *psm* population and those with an *asl* pore is much higher than any within-group distance (Table 7) and it is comparable with between-group distances (Table 8). On the other hand, in the case of expansion segments 28s-D2-D3, the distance between the group of three *A. italicum* specimens with a *psm* pore (from Austria) and those with an *asl* pore is 0.077 (Table 8). This value is close to the within-group distance calculated for *asl* specimens (0.075 in Table 7) and lower than the other between-group distances (Table 8).

DISCUSSION

The traditional morphometric analyses for this paper were limited to few characters. We focused on those characters that, based on a recent redescription of *A. italicum* (Galli *et al.*, 2016) and on our experience, seemed to be the most promising in order to highlight differences between *psm* and *asl* populations. In particular two foretarsal sensilla (*a* and *b*) are among the most important characters for *Acerentomon* species identification (see Shrubovych *et al.*, 2016), especially in those species assumed to be close to *A. italicum* (see Galli *et al.*, 2016). Therefore the absolute and relative length of these sensilla (to the tarsus and between them) was added to the structures that are traditionally measured. However, their between-group differences are not statistically significant. Just two size variables (tarsus and claw length) differ significantly between the two groups examined. Even though we did

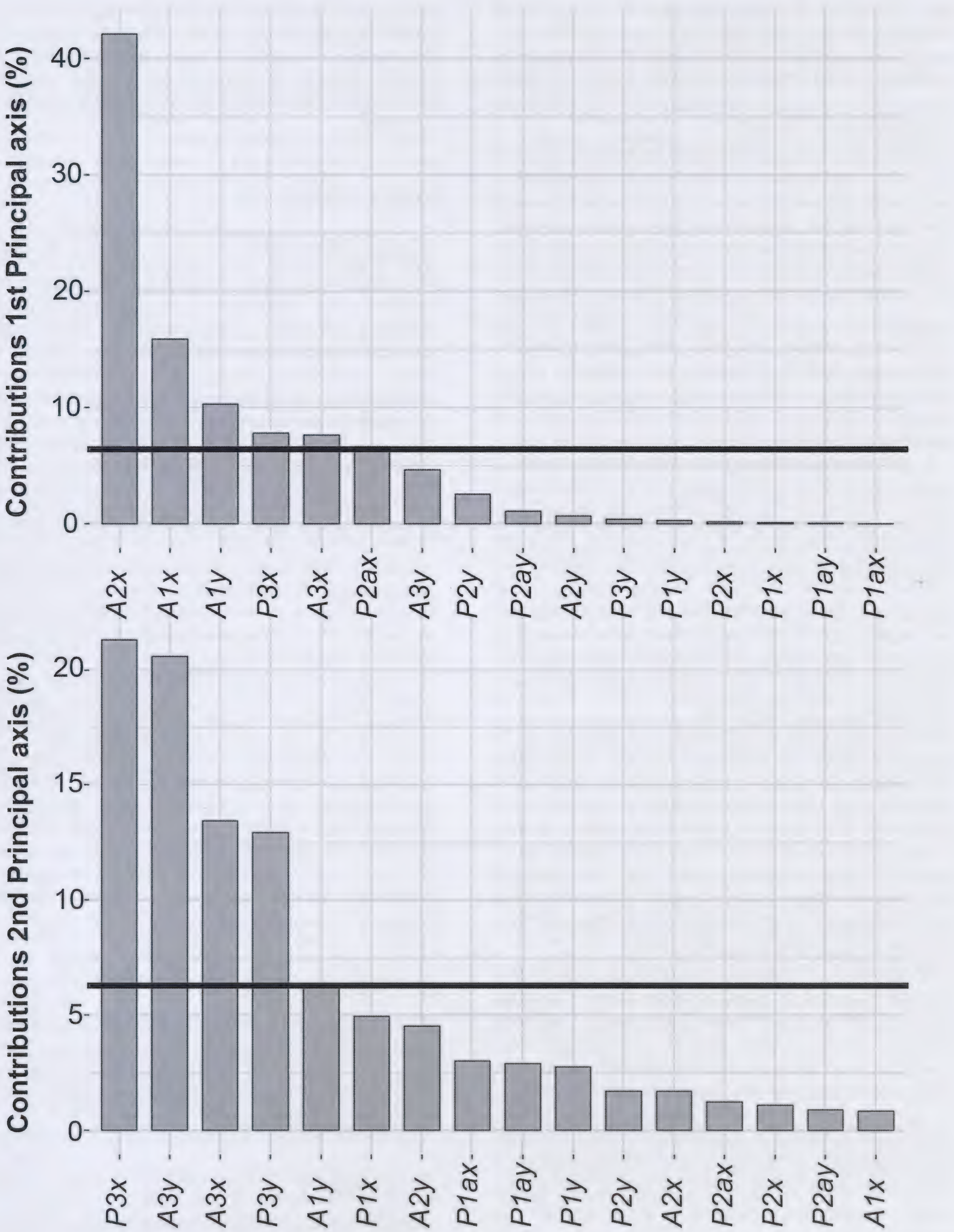

Fig. 8. Barplot showing the contribution of variables (expressed as percentage) along the first and second principal axes. The thick reference lines correspond to the expected value if the contributions were uniform. On the abscissa are the x and y coordinates of selected landmarks (setae *A1* to *A3* and *P1* to *P3*, see Fig. 2).

not outline any geographical trend for the examined variables, we cannot exclude that this may be due to the small sample examined. This could also be the reason for not having found differences in morphological characters which are of diagnostic importance in Acerentomidae (see Shrubovych, 2014).

Generally geometric morphometric analyses were applied to medium- and large-sized animals, and in hexapods they often dealt with wing venation. In the extensive literature dealing with this method, only few papers are about microscopic animals or about chaetotaxy (Mutanen *et al.*, 2009; Ramírez-Sánchez *et al.*, 2016; Theska *et al.*, 2020). This study therefore is the first one in which a geometric morphometric approach is applied to Protura and one of the first ever to deal with setae arrangement and microscopic animals. Geometric morphometrics allows to analyze shapes without having almost any information about size. This approach avoids potential bias generated by intra- and even inter-population variation that can be caused by sexual dimorphism, which is quite common among arthropods. Both explorative (PCA) and inferential (ANOVA) techniques highlight differences between the arrangement of setae on tergite VII in the two groups examined. Results from PCA showed that the largest variation is found in the arrangement of setae *A2*, *A3* and *P3*. Shape-related variation apparently does not depend on the variation of size-related elements as shown by regressions. When groups were compared, significant differences between populations were clearly highlighted by the Goodall test.

Both morphometry and geometric morphometrics do not show significant differences between sexes within each group. This confirms what was already highlighted by Galli *et al.* (2016) who examined all morphometric characters of *A. italicum* traditionally used in Protura taxonomy. However, Table 3 shows that females are on average slightly bigger than males. This size difference was evidenced also in other species of Acerentomidae like *Acerentulus shrubovychae* Galli & Capurro, 2013 and *Acerentulus tortii* Galli *et al.*, 2017.

The existence of species complexes in Protura was already suggested by Fratello & Sabatini (1989) on the basis of differences between kariotypes of different *Eosentomon transitorium* Berlese, 1908a populations. A species-level diversification can also be assumed for allopatric populations of some species that were likely separated by ancient vicariance events, as it is the case in the amphi-Atlantic *Delamarentulus tristani* (Silvestri, 1938) (see Galli & Rellini, 2020). Theoretically DNA barcoding could be an excellent tool to distinguish cryptic species, and in some cases it was used for that purpose since the early days (e.g. Herbert *et al.*, 2004). On the other hand, it was soon shown that especially for insufficiently sampled taxa (such as Protura) barcoding performs poorly when used for species identification (e.g. Meyer & Paulay, 2005). Our results must therefore be considered with extreme caution, especially in relation to the conflicting data from the analysis of COI-5P and 28S-D2-D3 sequences. For the latter some studies show that the more variable D2 region is more suitable not only for inferring relationships but also for taxonomic and diagnostic purposes at species level (e.g. Schmidt *et al.*, 2006).

CONCLUSIONS

Our integrative analyses show that *psm* and *asl* populations of *A. italicum* differ for some characters other than the porotaxy of tergite VII. In particular *psm* specimens are characterized by significantly longer foretarsi and claws. The geometric morphometric analysis of the arrangement of setae on tergite VII allows to discriminate between these populations both in descriptive and inferential terms, leaving no doubt about the shape difference between *asl* and *psm* groups. Their DNA barcode sequences COI-5P differ at an interspecific level. These data show a clear difference between the studied groups. However, it is worth pointing out that only a small sample from the available localities has been studied, with few specimens selected for each. It would be better to include more localities and more specimens. Moreover, only a single DNA sequence was available for the *psm* group. At present there is therefore not enough evidence to differentiate the two groups at the species level with reasonable certainty.

Nevertheless this study is the first one in which a geometric morphometric approach was applied to Protura, and one of the first ever to deal with the arrangement of setae and microscopic animals. Beyond the result in itself, it is important to show that this methodology can be applied to the study of evolutionary patterns and trends of chaeto- and porotaxy in Protura in addition to the traditional morphometric approach and to the genetic one. This is particularly useful when genetic data indicate significant differences between populations which supposedly belong to the same species.

ACKNOWLEDGEMENTS

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REFERENCES

Abdi H., Williams L.J. 2010. Principal component analysis. *Wiley interdisciplinary reviews: computational statistics* 2(4): 433-459.

Adams D., Rohlf F., Slice D. 2013. A field comes of age: geometric morphometrics in the 21st century. *Hystrix, the Italian Journal of Mammology* 24(1): 7-14.

Adams D., Collyer M., Kaliontzopoulou A. 2020. "Geomorph:

Software for geometric morphometric analyses. R package version 3.2.1. Available at https://cran.r-project.org/package=geomorph

Berlese A. 1908a. Nuovi Acerentomidi. *Redia* 5: 16-19, pl. I.

Berlese A. 1908b. Osservazioni intorno agli Acerentomidi. Nota preventiva. *Redia* 5: 110-122.

Bookstein F.L. 1997. Landmark methods for forms without landmarks: morphometrics of group differences in outline shape. *Medical Image Analysis* 1(3): 225-243.

Dryden I.L., Mardia K.V. 1998. Statistical shape analysis. *Wiley, Chichester,* xvii+347 pp.

Fratello B., Sabatini M.A. 1989. Chromosome studies in Protura Eosentomoidea (pp. 167-170). *In:* Dallai R. (ed.). 3rd International Seminar on Apterygota. *University of Siena*, Siena, 489 pp.

Galli L., Capurro M. 2013. *Acerentulus shrubovychae* sp. nov. from Italy (Protura: Acerentomidae). *Zootaxa* 3609 (4): 431-436.

Galli L., Rellini I. 2020. The geographic distribution of Protura (Arthropoda: Hexapoda): a review. *Biogeographia – The Journal of Integrative Biogeography* 35: 51-69.

Galli L., Bartel D., Capurro M., Pass G., Sarà A., Shrubovych J., Szucsich N. 2016. Redescription and review of the most abundant conehead in Italy: *Acerentomon italicum* Nosek, 1969 (Protura: Acerentomidae). *Italian Journal of Zoology* 83(1): 43-58.

Galli L., Capurro M., Lionetti G., Zinni M. 2017. *Acerentulus tortii* sp. nov. from Greece (Protura: Acerentomidae). *Zootaxa* 4232(3): 437-443.

Goodall C. 1991. Procrustes methods in the statistical analysis of shape. *Journal of the Royal Statistical Society* Series B (Methodological) 53(2): 285-321.

Hammer Ø., Harper D.A.T., Ryan P.D. 2001. PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica* 4: 1-9. Available at http://folk.uio.no/ohammer/past

Herbert P.D.N., Penton E.H., Burns J.M., Janzen D.H., Hallwachs W. 2004. Ten species in one: DNA barcoding reveals cryptic species in the neotropical skipper butterfly *Astraptes fulgerator*. Proceedings of the National Academy of Sciences 101(41): 14812-14817.

Jolliffe I.T. 2002. Principal component analysis (2nd ed.). *Springer, New York,* 516 pp.

Kassambara A., Mundt F. 2017. Package 'factoextra'. Extract and visualize the results of multivariate data analyses, 76. Available at http://www.sthda.com/english/rpkgs/factoextra

Kendall D.G. 1984. Shape manifolds, Procrustean metrics, and complex projective spaces. *Bulletin of the London Mathematical Society* 16: 81-121.

Kimura M. 1980. A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. *Journal of Molecular Evolution* 16: 111-120.

Kumar S., Stecher G., Tamura K. 2016. MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. *Molecular Biology and Evolution* 33: 1870-1874.

Meyer C.P., Paulay G. 2005. DNA Barcoding: error rates based on comprehensive sampling. *PLoS Biology* 3(12): e422.

Mutanen M., Ruotsalainen H., Kaila L. 2009. Variation in larval chaetotaxy in *Orthosia gothica* (Lepidoptera: Noctuidae): effects of mother, sex and side, and implication for systematics. *Systematic Entomology* 34: 712-723.

Nosek J. 1969. Three new species of Protura from Italy. *Atti dell'Istituto Veneto di Scienze, Lettere ed Arti. Classe di Scienze matematiche e naturali* 127: 485-494.

Nosek J. 1973. European Protura. *Muséum d'Histoire naturelle, Genève,* 345 pp.

R Core Team, 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at https://www.R-project.org/

Ramírez-Sánchez M.M., De Luna E., Cramer C. 2016. Geometric and traditional morphometrics for the assessment of character state identity: multivariate statistical analyses of character variation in the genus *Arrenurus* (Acari, Hydrachnidia, Arrenuridae). *Zoological Journal of the Linnean Society* 177(4): 720-749.

Ripley B., Venables B., Bates D.M., Hornik K., Gebhardt A., Firth D., Ripley M.B. 2013. Package 'mass'. Cran R, 538. Available at https://cran.r-project.org/web/packages/MASS/index.html

Rohlf F.J. 2017a. tpsUtil32. New York: Department of Ecology and Evolution, State University of New York at Stony Brook. Available at http://life.bio.sunysb.edu/morph/

Rohlf F.J. 2017b. TpsDig, version 2.30. New York: Department of Ecology and Evolution, State University of New York at Stony Brook. Available at http://life.bio.sunysb.edu/morph/

Rohlf F.J., Slice D. 1990. Extensions of the Procrustes method for the optimal superimposition of landmarks. *Systematic Biology* 39(1): 40-59.

Schmidt S., Driver F., De Barro P. 2006. The phylogenetic characteristics of three different 28S rRNA gene regions in *Encarsia* (Insecta, Hymenoptera, Aphelinidae). *Organisms, Diversity & Evolution* 6: 127-139.

Shrubovych J. 2014. Identification and character analysis of the Acerentomidae (Protura) of the northeastern Palearctic (Protura: Acerentomidae). *Zootaxa* 3755(2): 136-164.

Shrubovych J., Bartel D., Szucsich N.U., Resch M.C., Pass G. 2016. Morphological and genetic analysis of the *Acerentomon doderoi* group (Protura: Acerentomidae) with description of *A. christiani* sp. nov. *PLoS ONE* 11(4): e0148033.

Silvestri F. 1938. Primo contributo alla conoscenza dei Protura (Insecta) del Brasile e di Costa Rica (pp. 441-445). *In:* Neiva A. (ed.). Livro Jubilar do Professor Lauro Travassos. Editato para commemorar o 25º anniversario de suas actividades scientificas (1913-1938). *Instituto Oswaldo Cruz, Rio de Janeiro*, 589 pp.

Szeptycki A. 1991. Polish Protura V. Genus *Acerentulus* Berlese, 1908 (Acerentomidae). *Acta Zoologica Cracoviensia* 34(1): 1-64.

Szeptycki A. 1993. *Gracilentulus* species of "*gracilis*" group (Protura, Berberentomidae). *Acta Zoologica Cracoviensia* 35(3): 381-411.

Theska T., Sieriebriennikov B., Wighard S.S., Werner M.S., Sommer R.J. 2020. Geometric morphometrics of microscopic animals as exemplified by model nematodes. *Nature Protocols* 15(8): 2611-2644.

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A revision of the Chilean Brachyglutini – Part 7. Revision of *Achilia* Reitter, 1890: *A. cosmoptera* species group (Coleoptera: Staphylinidae: Pselaphinae)

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Abstract: The *Achilia cosmoptera* species group *sensu* Jeannel (1962) of the species-rich genus *Achilia* Reitter, 1890 is revised. Of the twelve taxa placed so far in this informal group, four species – *A. andina* Franz, 1996, *A. maiopensis* Franz, 1996, *A. pseudangularis* Franz, 1996, and *A. quinteroi* Franz, 1996 – belong to different genera and will be treated in forthcoming papers, and one name is placed in synonymy – *A. picea* Raffray, 1904 = *A. elfridae* Raffray, 1904 **syn. nov.** The remaining seven species are redescribed, and three new species fitting the concept of the *A. cosmoptera* group are described – *A. covidia* **n. sp.**, *A. pandemica* **n. sp.**, and *A. quarantena* **n. sp.** The lectotypes of *A. cosmoptera* (Blanchard, 1851), *A. blanchardi* Raffray, 1904, *A. elfridae* Raffray, 1904, *A. bifrons* Jeannel, 1962, and *A. nahuelbutae* Franz, 1996 are designated, and the new synonymies *A. nahuelbutae* Franz, 1996 = *A. angularis* Jeannel, 1962 **syn. nov.**, and *A. caneloi* Franz, 1996 = *A. temporalis* Jeannel, 1962 **syn. nov.** are also established. For all these species of the *A. cosmoptera* group their distribution is detailed and mapped, and habitat/collecting data are summarized.

Keywords: *Achilia* - Chile - taxonomy - new species - distribution.

INTRODUCTION

This article is the seventh contribution to our series aiming at a taxonomic revision of the Brachyglutini of the temperate region of southern South America, and the sixth dedicated to the genus *Achilia* Reitter, 1890 (Kurbatov & Sabella, 2015; Sabella *et al.*, 2017; Kurbatov *et al.*, 2018; Sabella *et al.*, 2019; Kurbatov *et al.*, 2019; Sabella *et al.*, 2020).

We here focus on the *A. cosmoptera* species group (*sensu* Jeannel, 1962). All the members of these group are critically reexamined and their synonymic framework is detailed, and these species are redescribed. Three new species placed in the group are described.

Regarding the prevalence of the spelling of the genus *Achilia* versus *Achillia* see Sabella *et al.* (2017: 120). The species groups of *Achilia* as defined by Jeannel (1962), which are mainly based on male sexual dimorphism, as well as their possible phylogenetic relationships will be reassessed later. A key to identification of the species of *Achilia* will be provided only at the end of this series of contributions.

MATERIAL AND METHODS

This study is based on the examination of 900 specimens. The acronyms used in the present study refer to the following collections (relevant curator/collection manager are acknowledged in parentheses):

DBUC	Department of Biological, Geological and Environmental Sciences, University of Catania, Italy
FMNH	Field Museum of Natural History, Chicago, U.S.A. (M. Turcatel)
HNHM	Hungarian Natural History Museum, Budapest, Hungary (O. Merkl)
JEBC	Colección Entomológica Y Museo Juan Enrique Barriga – Tuñón, Curicó, Chile (J. E. Barriga – Tuñón)
MHNG	Muséum d'Histoire Naturelle, Genève, Switzerland
MNHN	Muséum National d'Histoire Naturelle, Paris, France (T. Deuve and A. Taghavian)
MNHS	Museo Nacional de Historia Natural, Santiago, Chile (M. Elgueta Donoso and Y. J. Sepulveda Guaico)

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MSNG Museo Civico di Storia Naturale "G. Doria", Genova, Italy (R. Poggi)
NHMW Naturhistorische Museum, Wien, Austria (H. Schillhammer)
PCTS Private collection of Tim Struyve, Mechelen, Belgium (T. Struyve)
PCVB Private collection of Volker Brachat, Geretsried, Germany (V. Brachat)
PHPC Private collection of Peter Hlavác, Prague, Czech Republic (P. Hlavác)
UNHC University of New Hampshire Arthropod Collection, Durham, NH, U.S.A. (D.S. Chandler).

Only critical references are cited for the species. Under the sections "type material" or "additional material" the locality data are standardized, with indications of major administrative units (Regions and Provinces) and names of collectors; for the holotypes of older specimens the labels are also given verbatim. For MHNG materials additional informations pertaining to sampling sites are enriched from unpublished locality lists when available.
For the method of selection of the type material see Sabella *et al*. (2017).
The aedeagi and other body parts illustrated here were mounted in Canada balsam on acetate slides, and drawn using a drawing tube mounted on a Zeiss Axioskop compound microscope. Images were taken using a Leica DFC425 camera in conjunction with a Leica M205-C compound microscope. Zerene Stacker (version 1.04) was used for image stacking. All images were modified and grouped using Adobe Photoshop CC and Illustrator CS6.
The body length is measured from the anterior clypeal margin to the posterior margin of the last visible abdominal tergite. The length and width of the body parts were measured between points of maximum extension, e.g. the head length is measured between the anterior clypeal margin and the posterior margin of the neck, the head width includes the eyes, the elytral length along the suture line, and the elytral width is the total width of the two elytra taken together. The abdominal tergites are numbered based on order of visibility. Morphological terminology follows that of Chandler (2001), except our use of 'ventrite' instead of 'sternite' when describing meso- and metathoracic structures, and that the sclerotized features of the aedeagus termed "dorsal strips" in Sabella *et al*. (2017) are here termed "longitudinal struts".

TAXONOMY

Achilia cosmoptera species group

Remarks: Jeannel (1962: 398, 425) characterized this group as follows: elytra with two basal foveae; basal striae of first abdominal tergite separated at most by a quarter of tergal width; frontal lobe of males modified, male's antennomeres unmodified; aedeagal parameres with long setae.

Franz (1996: 118) proposed a new group of species – i.e. the *A. angularis* group – to accomodate *Achilia* species in which the internal sac of aedeagus bears a complex of ramified spines. In addition to *A. angularis*, previously attributed by Jeannel (1962: 426) to the *A. cosmoptera* group, he included in this new group *A. pseudangularis* Franz, 1996, *A. quinteroi* Franz, 1996, *A. andina* Franz, 1996 and *A. maiopensis* Franz, 1996. However the delimitation of this *A. angularis* group overlaps that of the *A. cosmoptera* group of Jeannel, and moreover Franz placed in it species having little in common in our opinion. For convenience we treat here all the species included by Franz in his *A. angularis* group as members of the *A. cosmoptera* group, which would thus consist of: *A. andina* Franz, 1996, *A. angularis* Jeannel, 1962, *A. bifrons* Jeannel, 1962, *A blanchardi* Raffray, 1904, *A. cosmoptera* (Blanchard, 1851), *A. elfridae* Raffray, 1904, *A. maiopensis* Franz, 1996, *A. melanocephala* Jeannel, 1963, *A. picea* Raffray, 1904, *A. pseudoangularis* Franz, 1996, *A. quinteroi* Franz, 1996, and *A. temporalis* Jeannel, 1962.
However, after examination of the types we concluded that *A. andina* Franz, 1996 and *A. maiopensis* Franz, 1996 resemble members of *Pseudachillia* Jeannel, 1964, while *A. pseudangularis* Franz 1996 and *A. quinteroi* Franz, 1996 resemble members of *Achillidia* Jeannel, 1962; we will deal in more depth with these four species as well as assess the opportunity of their transfer in our forthcoming reviews of these genera. Also, one name is placed in synonymy – *Achilia picea* Raffray, 1904 = *Achilia elfridae* Raffray, 1904 (**syn. nov.**). As a result, the *A. cosmoptera* group is reduced to *A. cosmoptera* (Blanchard, 1851), *A. blanchardi* Raffray, 1904, *A. elfridae* Raffray, 1904, *A. bifrons* Jeannel, 1962, *A. temporalis* Jeannel, 1962, *A. angularis* Jeannel, 1962, and *A. melanocephala* Jeannel, 1963, to which we add three new species described below – i. e. *A. covidia* n. sp., *A. pandemica* n. sp. and *A. quarantena* n. sp. – for a total of ten species.
The species of the *A. cosmoptera* group possess the following common features: pubescence decumbent, consisting of long setae sparse over the body, and very sparse on the elytra (except in *A. bifrons, A. temporalis,* and *A. angularis*); head distinctly wider than long (only slightly wider than long in *A. angularis* and *A. quarantena* n. sp.) with two big vertexal foveae, eyes fairly protruding and longer than temples; antennae with antennomeres III-VIII about the same width; pronotum wider than long, slightly wider than head, and with slightly convex disc, its surface smooth and shiny with some punctures; median antebasal fovea slightly smaller than lateral foveae; anterior portion of lateral margins of pronotum distinctly convergent and sinuate anteriorly; posterior portion of lateral margins of pronotum slightly convergent; basal margin of pronotum bordered with row of contiguous shallow impressions; elytra together wider than long with protruding humeri; elytral disc smooth, shiny, with very

few punctures (except in *A. angularis* for which they are more densely punctate); elytra with two big basal foveae, sometimes with two small more medial foveae (as for example in the holotype of *A. melanocephala*); sutural stria entire; elytral discal stria extended to about elytral mid-length; abdomen smooth, with some minute punctures; first abdominal tergite with diverging basal striae extending to about one-fourth of paratergal length (except in *A. angularis* in which they are longer than one-fourth of paratergal length), and separated at base by about one-fourth of tergal width (except in *A. angularis*, *A. pandemica* n. sp. and *A. melanocephala*, in which they are wider than one-fourth of tergal width); short and sparse setal brush between basal striae. Many specimens of both sexes of *A. cosmoptera*, *A. elfridae*, *A. pandemica* n. sp. and *A. angularis* bear also a bundle of long setae on lateral side of first visible abdominal sternite (see Figs 49-50: arrows).

In order to keep the text more concise, these features are not repeated in their respective descriptions.

Achilia angularis Jeannel, 1962

Figs 8-12, 15, 21, 24, 30, 32, 33-36, 64

Achilia angularis Jeannel, 1962: 426, 430, figs 198 (head and antenna of male), 199 (aedeagus).

Achilia nahuelbutae Franz, 1996: 115, fig. 62 (aedeagus) **syn. nov.**

Type material (2 ex.): CENTRAL CHILE: Región Bío Bío: Ñuble Prov.: MNHN; 1 ♂ (holotype of *A. angularis*); labels verbatim "Holotype / Chile; Chillan / *Achillia angularis* (handwritten by Jeannel)". – Región Araucanía: Malleco Prov.: NHMW; 1 ♂ (lectotype of *A. nahuelbutae*, here designated); labels verbatim "Lectotype / Cordillera; Nahuelbuta; lg. H. Franz / *Achillia nahuelbutae* m. (handwritten by Franz) / *Achilia nahuelbutae* Franz, 1996 = *Achilia angularis* Jeannel 1962; det. Sabella, Cuccodoro & Kurbatov 2019".

Additional material examined (244 ex.): SOUTHERN ARGENTINA: Neuquén Prov.: MNHN; 1 ♂; San Martín de los Andes; 15.IV.1959; C. Delamare. – CENTRAL CHILE: Región Araucanía: Cautín Prov.: FMNH (FMHD# 96-239); 1 ♂ and 2 ♀; Villarica National Park, Volcán Villarica, road to sky center; 39° 22.48'S 71° 58.30'W; 1180 m; 26.XII.1996; *Nothofagus dombeyi* forest w/*Chusquea*, Berlese, leaf & log litter; A. Newton & M. Thayer 980. – MHNG; 1 ♂; Villarica National Park, Volcán Villarica, 10 km S Pucón; 900 m; 15.XII.1984/10.II.1985; *Nothofagus* grove on ash; S. & J. Peck. – PCVB; 1 ♂; Pucón, Volcán Villarica; 1300 m; 23.XI.2004; Bergwald; K. Renner. – UNHC; 3 ♂; Volcán Villarica; 1250 m; site 653; 15-29.XII.1982; *Nothofagus dombeyi pumilio* forest w/*Chusquea*, Berlese, leaf & log litter, forest floor; A. Newton & M. Thayer. – PCTS; 1 ♂; Palguin, 39,43°S 71,79°W; 05.XII.2013; litter layer. – MHNG; 5 ♂ and 17 ♀; Huerquehue National Park; 800-900 m; station 16a; 22-24.XII.1980; forest litter; D. Agosti & D. Burckhardt. – FMNH (FMHD# 96-232); 1 ♂; Conguillío National Park, 4.0 km E Laguna Captrén guard sta.; 38° 38.98'S 71° 39.77'W; 1255 m; 23.XII.1996; *Nothofagus dombeyi* forest, Berlese, flood debris along stream; A. Newton & M. Thayer. – Malleco Prov. – MHNG; 1 ♂; Cordillera Nahuelbuta; H. Franz. – NHMW; 6 ♂ (2 identified as *A. nahuelbutae*) and 39 ♀; same data. – MHNG; 3 ♂; Nahuelbuta National Park, 40 km W Angol; 1200-1500 m; 19.XII.1984/17.II.1985; *Nothofagus-Araucaria*; for FIT; S. & J. Peck. – MHNG; 8 ♂; Nahuelbuta National Park, 45 km W Angol; 1400 m; 09.XII.1984/16.II.1985; *Nothofagus-Araucaria* forest, car trap; S. & J. Peck. – FMNH (FMHD P#85-13); 1 ♂; same locality; 09.XII.1984; *Nothofagus-Araucaria* forest, Berlese, litter; S. & J. Peck. – JEBC; 2 ♂; National Park, Nahuelbuta (entrance); 37° 49.555'S 72° 58.008' W; III.2001; soil; J. E. Barriga-Tuñón. – JEBC; 1 ♂; National Park, Nahuelbuta; 36° 52' 34"S 71° 28' 3"W; 06.XII.2008; fogging lenga *Nothofagus obliqua*; J. E. Barriga-Tuñón. – JEBC; 1 ♂ and 2 ♀; Arauco, National Park Nahuelbuta, Pichinahuel; 37° 47'S 73° 00'W; 1200 m; 22.IX.2001; Berlese trap, *Araucaria araucana*; J. E. Barriga-Tuñón. – FMNH (FMHD #2002-041); 2 ♂ and 7 ♀; Nahuelbuta National Park, E of Guarderia Pichinahuel; 37° 48.20'S 73° 01.41'W; 1290 m; 05-24.XII.2002; *Araucaria-Nothofagus dombeyi* with *Chusquea* bamboo, flight intercept trap; A. Newton, M. Thayer, A. Solodovnikov; D. J. Clarke & M. Chani 1054. – MHNG; 2 ♂ and 2 ♀; same data. – FMNH (FMHD #2002-042); 1 ♀; same data but carrion trap (octopus); M. Thayer & A. Newton 1054. – FMNH (FMHD #2002-054); 6 ♂ and 52 ♀; Nahuelbuta National Park, Comallín area, between Guardería and picnic area; 37° 48.33'S 73° 00.98'W; 1200 m; 06.XII.2002; *Nothofagus-Araucaria*-bamboo, sun-extracted, sifted litter; A. Solodovnikov. – MHNG; 3 ♂ and 6 ♀; same data. – FMNH (FMHD #2002-053); 1 ♂ and 21 ♀; same data but pitfall traps (10); A. Solodovnikov. – MHNG; 1 ♂ and 3 ♀; same data. – FMNH (FMHD #96-219); 2 ♂; Nahuelbuta National Park, Comallín, 8.2 km NW Los Portones entrance; area; 37° 48.21'S 73° 00.89'W; 1260 m; 21.XII.1996/07.II.1997; *Nothofagus* spp. *Araucaria araucana* forest, flight intercept trap; A. Newton & M. Thayer 974. – MHNG; 2 ♂; same data. – FMNH (FMHD #96-221); 2 ♂; same data but 21.XII.1996; leaf & log litter. – MHNG; 1 ♂; same data. – FMNH (FMHD #96-222); 2 ♂; Nahuelbuta National Park, 4.5 km W Los Portones entrance; 37° 49.25'S 72° 59.82'W; 1300 m; 21.XII.1996/07.II.1997; *Nothofagus* spp. emergent *Araucaria araucana, Chusquea* understory, flight intercept trap; A. Newton & M. Thayer 975. – MHNG; 1 ♂; same data. – FMNH (FMHD #96-224); 1 ♂ and 3 ♀; same data but 21.XII.1996; Berlese, leaf & log litter. – FMNH (FMHD #97-48); 3 ♂ and 8 ♀; Nahuelbuta National Park, 2.3 km W Los Portones entrance; 37° 49.32'S 72° 58.73'W; 1190 m; 07.II.1997; *Nothofagus* spp. forest (evergreen and deciduous), Berlese, leaf & log litter; A. Newton & M. Thayer, 1010. – FMNH (FMHD #2002-051); 1 ♂ and 1 ♀; Nahuelbuta National Park, Comallín, 8.2 km NW Los Portones entrance area; 37° 48.10'S 73° 00.93'W; 1210 m; 06.XII.2002; *Nothofagus antarctica* w/ *Araucaria* & *Chusquea* bamboo, sun-extracted, leaf & log litter; A. Solodovnikov 1058. – FMNH (FMHD #2002-052); 3 ♀; same data but 06-08.XII.2002; pitfall trap (10). – FMNH (FMHD #2002-056); 3 ♂; Nahuelbuta National Park, 2.3 km W Los Portones entrance; 37° 49.41'S 72° 58.95'W; 1150 m; 07-25.XII.2002; *Nothofagus dombeyi* + *antarctica*, mostly open understory, flight intercept trap; A. Newton & M. Thayer 1057. – MHNG; 2 ♂; same data. – FMNH (FMHD #2002-045); 1 ♂; Nahuelbuta National Park, road to Piedra del Águila; 37° 49.29'S 73° 01.90'W; 1360 m; 06-24.XII.2002; *Nothofagus dombeyi* & *pumilio*, large *Araucaria*, bamboo + shrub understory, flight intercept trap; M. Thayer, A. Newton, A. Solodovnikov, D. J. Clarke & M. Chani 1055. – FMNH (FMHD #2002-048); 1 ♂ and 4 ♀; Nahuelbuta

National Park, Vic Pehuenco (Centro Visitantes); 37° 49.06'S 73° 00.47'W; 1130 m; 06-25.XII.2002; *Nothofagus* sp. (decid.), w/shrubby understory, no bamboo, flight intercept trap; M. Thayer, A. Newton, A. Solodovnikov, D. J. Clarke & M. Chani 1056.

Description: Body 1.35-1.65 mm long, reddish with darkened head and abdomen; antennae and legs reddish; palpi yellowish.
Male: Head as in Figs 33-36, subrectangular with slightly convex occipital region; frons and frontal lobe punctate; transverse frontal sulcus narrow and shallow, limited to the area posterior to antennal tubercles; temporal angles prolonged as spiniform process directed upwards. Antennae (Fig. 21) with scape distinctly longer than wide; pedicel slightly longer than wide; antennomere III slightly wider than long; antennomeres IV-VIII wider than long; antennomere IX wider than VIII and wider than long, with some tubercles and setae; antennomere X distinctly wider than long and wider than IX, with some tubercles and setae; antennomere XI moderately elongate, longer than VIII-X combined. Metaventrite with very shallow mediobasal impression. First abdominal sternite slightly raised and flattened at middle. Profemora (Fig. 15) enlarged and densely pubescent; protibiae (Fig. 24) with distal half swollen and densely pubescent, with acute apical spine; mesotibiae (Fig. 30) with distal half slightly bulging, with group of dense setae near basal third of medial margin, medial margin indented and ending as subapical spine; metatibiae (Fig. 32) with medial margin expanded on basal third as pubescent lamina and ending with very short subapical spine. Aedeagus (Fig. 8) 0.25-0.26 mm long, with ovoidal dorsal plate; dorsal longitudinal struts divergent. Parameres relatively wide with one seta on short outer lobe; apical portion of parameres recurved anteriorly, bearing one ventral medial seta. Copulatory pieces consisting of two subequal sclerites basally recurved and more robust, and apically pointed with some short subapical spines; these sclerites associated with two lateral sclerites variable in shape and forming apically two or three spines (Figs 8-12).
Female: Similar to male except head not modified; antennae shorter; eyes smaller; metaventrite, abdominal sternites, and legs unmodified.

Collecting data: Collected from December to April; found in different types of forests of *Nothofagus* spp., sometimes with *Araucaria araucana* and *Chusquea* at elevations ranging from 800 m to 1500 m. Most of the material come from sifted samples of leaf and log litter; some specimens were collected with pitfall traps, and several males have also been collected by flight intercept traps, and car netting.

Distribution: *Achilia angularis* is known from Southern Argentina (Neuquén Prov.) and Central Chile (Araucanía and Bío Bío Regións) (Fig. 64: squares edged in blue).

Comments: In a previous article (Sabella *et al.*, 2017: 123) we claimed to have examined the type series of *Achilia nahuelbutae* Franz, 1996 housed in the NHMW, which included three different species of *Achilia* and one specimen of the tribe Euplectini; all 56 specimens are labeled as "Cordillera Nahuelbuta / lg. H. Franz.". In the original description Franz (1996: 115) mentions a holotype male and 39 paratypes, but in Franz's collection none of the specimens examined bear holotype or paratypes labels, and only 3 males – the only specimens dissected and pinned with the aedeagus preparation – have an identification label handwritten by Franz "*Achillia nahuelbutae* m.". Among these three males, which are very similar both in exoskeletal morphology and the shape of the aedeagus, we designate one as the lectotype of *A. nahuelbutae* Franz, 1996. The comparison between this lectotype of *A. nahuelbutae* Franz, 1966 and the holotype of *A. angularis* Jeannel, 1962 showed that they are conspecific, and therefore we place *Achilia nahuelbutae* Franz, 1996 as a junior synonym of *A. angularis* Jeannel, 1962 (**syn. nov.**). The remaining 54 specimens, excluding the member of Euplectini, belong to *A. angularis* (3 male and 30 females), to *A. jeanneli* Sabella, Cuccodoro & Kurbatov, 2019 (1 male and 15 females), to *A. pachycera* Jeannel, 1963 (3 females), and to *A. bicornis* Jeannel, 1962 (2 females).
The males of *A. angularis* are easily distinguished from those of the other species of the *A. cosmoptera* group by the shape of the head (Figs 33-36), antennae (Fig. 21), profemora (Fig. 15), protibiae (Fig. 24), mesotibiae (Fig. 30), metabiae (Fig. 32), and aedeagus (Fig. 8). The females of *A. angularis* strongly resemble those of *A. quarantena* n. sp.; for characters to distinguish females of these two species see the "Comments" section of the latter species.

Achilia bifrons Jeannel, 1962
Figs 5, 18, 37, 39, 41, 63

Achilia bifrons Jeannel, 1962: 426, 428, fig. 192 (aedeagus).

Type material (2 ex.): CENTRAL CHILE: Región Bío Bío: Concepción Prov.: MHHN; 1 ♂ (Lectotype, here designated) labels verbatim "Lectotype / Boca del Biobio / Concepcion; 26.V.1957 / *Achillia bifrons* (handwritten by Jeannel)". – MNHN, 1 ♂ (Paralectotype, here designated); labels verbatim "Paralectotype / El Caracol; Conc.; 26.V.1957 / 2 Fb".

Additional material examined (4 ex.): CENTRAL CHILE: Región Bío Bío: Concepción Prov.: MSNG; 1 ♂ and 1 ♀; Lomas Coloradas; 21.V.1988; site TC- 208; T. Cekalovic. – MHNG; 1 ♂ and 1 ♀; same data.

Description: Body 1.55-1.60 mm long, entirely reddish with slightly darkened abdomen; palpi yellowish.
Male: Head as in Figs 37, 39 & 41, wide, surface with scattered punctures; occipital region and basal half of frons raised with U-shaped median notch; basal half of

frons very long and convex, and separated from distal half of frons by transverse sulcus; anterior margin of this sulcus raised and pointed at middle, bearing tuft of long setae. Antennae (Fig. 18) with scape and pedicel longer than wide; antennomeres III-IV slightly longer than wide; antennomeres V-VII longer than wide; antennomere VIII about as long as wide; antennomere IX only slightly wider than VIII and slightly wider than long; antennomere X wider than long and wider than IX; antennomere XI elongate, about as long as VII-X combined. Metaventrite with wide medial sulcus on apical on two-thirds, sulcus densely pubescent. Mesotibiae with distal half swollen and densely pubescent. Aedeagus (Fig. 5) 0.31-0.32 mm long, with subrectangular dorsal plate slightly narrowed apically; dorsal longitudinal struts slightly divergent. Parameres relatively wide with large and long recurved seta on well-developed and relatively long outer lobe; apical portion of parameres slightly recurved anteriorly; apex bearing one ventral medial seta. Copulatory pieces consisting of two subequal bifid sclerites basally recurved and more robust, topped with medial sclerites with rounded apical sides.

Female: Similar to male except head not modified; antennae shorter; eyes smaller; metaventrite, and legs unmodified.

Collecting data: The data in our possession do not allow statements in this regard other than members of this species are active in May.

Distribution: *Achilia bifrons* is only known from Concepción Province (Región Bío Bío) (Fig. 63: blue inverted triangles).

Comments: Jeannel (1962: 428) described *A. bifrons* on the basis of two males collected in Concepción Province, respectively at Bocas del Biobio and at Cerro Caracol. He stated that the holotype of *A. bifrons* was housed in the MNHS and the paratype in the MNHN. However in the MNHS we couldn't find any specimens of *A. bifrons*, and moreover this taxon is not listed in the catalog of the MHNS holotypes of insects (Camousseight, 1980). Instead we found in the MNHN two males of this species identified as such by Jeannel and labeled as from Bocas del Biobio and Cerro Caracol, but not bearing any type labels. Considering that Jeannel (1962: 428) indicated the type locality as generically from Concepción, we designate here the male labeled "Boca del Biobio / Concepcion; 26.V.1957 / *Achillia bifrons* (handwritten by Jeannel)" as the lectotype of *A. bifrons*, and the other male from Cerro Caracol as paralectotype.

The males of *A. bifrons* are easily distinguished from other species of the *A. cosmoptera* group by the shape of the head (Figs 37, 39, 41), antennae (Fig. 18), and aedeagus (Fig. 5). The females of this species are similar to those of *A. temporalis* from which they can be easily distinguished by their very long frontal lobe with the anterior margin slightly pointed at the middle, while the frontal lobe is short with a straight anterior margin in *A. temporalis*.

Achilia blanchardi Raffray, 1904

Figs 3, 17, 27, 38, 40, 42, 63

Bryaxis valdiviensis Reitter, 1883: 50, pl. 1 fig. 8 (head and antenna) (nec *valdiviensis* Blanchard, 1851). – Reitter, 1885: 326; 330, pl. 2 fig. 14 (head and antenna).

Achilia clavata Raffray, 1904: 137, fig. 53 (head and antenna) (synonymized by Jeannel, 1962: 429).

Achilia blanchardi Raffray, 1904: 138 (new name for *Bryaxis valdiviensis* Reitter, 1883). – Jeannel, 1962: 426, 430, figs 195 (head and antenna of male), 196 (head and antenna of female), 197 (aedeagus).

Type material (12 ex.): MNHN; 1 ♀ (Holotype of *A. clavata*); labels verbatim "Museum de Paris; 1917; coll. Raffray / Chili / Type / *clavata*; det. A. Raffray / *clavata* (handwritten by Jeannel)". – SOUTHERN CHILE: Región Los Ríos: Valdivia Prov.: MNHN; 1 ♂ (lectotype of *A. blanchardi* here designated); labels verbatim "Lectotype / Type / 1880; Chili; Valdivia; leg. Kindermann/ *Bryaxis*; *valdiviensis*; m. Valdivia / Museum de Paris; 1917; coll. Raffray / *A. blanchardi*; A. Raffray det.". – MNHN; 1 ♂ and 9 ♀ (Paralectotypes of *A. blanchardi* here designated); labels verbatim "Paralectotype / Chili / Museum de Paris; 1917; coll. Raffray / *A. blanchardi*; A. Raffray det.".

Additional material examined (5 ex.): FMNH; 1 ♀; Field Mus. Nat. Hist.; Orlando Park; Pselaphidae Colln.; F. C. Fletcher Collection. – MNHN; 1 ♀; Chile; P. Germain. – HNHM; 1 ♂; "Chili". – MNHN; 2 ♀; "Chili"; Gay; 1849.

Description: Body 1.35-1.40 mm long, dark brown with reddish elytra; antennae and legs reddish; palpi yellowish.

Male: Head as in Figs 38, 40 & 42, very wide, surface with some very scattered punctures; occipital region raised, frons flattened and separated by large transverse sulcus from large frontal lobe; anterior margin of frontal sulcus slightly raised and pointed at middle. Antennae (Fig. 17) with scape and pedicel longer than wide; antennomere III distinctly longer than wide; antennomere IV about as long as wide; antennomeres V-VII slightly longer than wide; antennomere VIII as long as wide; antennomere IX wider than VIII and wider than long; antennomere X distinctly wider than long, shorter and wider than IX; antennomere XI elongate, longer than VII-X combined. Metaventrite with deep and wide transverse sulcus on apical two-thirds, sulcus with deflected and posteriorly prominent margins forming sort of tubercles. First abdominal sternite slightly raised and flattened at middle; remaining abdominal sternites slightly flattened at middle. Protibiae with distal half slightly swollen; mesotibiae (Fig. 27) with distal half swollen and densely pubescent. Aedeagus (Fig. 3) 0.23 mm long, with dorsal plate subrectangular; dorsal longitudinal struts divergent. Parameres relatively wide with very large and long recurved seta on well-developed outer lobe, this seta bifid and very swollen

on basal third; apical portion of parameres slightly recurved anteriorly and prolonged laterally at tip; apex of parameres bearing one long ventral medial seta associated with wider and shorter seta. Copulatory pieces consisting of two subequal short sclerites slightly enlarged apically, recurved and more robust basally.
Female: Similar to male except head not modified; antennae shorter with antennomere XI shorter; metaventrite, abdominal sternites, and legs unmodified.

Collecting data: The data in our possession do not allow us to make statements in this regard.

Distribution: *Achilia blanchardi* is only known from Valdivia (Región Los Ríos: Valdivia Prov.) (Fig. 63: green diamonds).

Comments: Raffray (1904: 138) proposed the new name *Achilia blanchardi* for *Bryaxis valdiviensis* Reitter, 1883, described on an unspecified number of specimens from Valdivia, because this name was preoccupied by *Pselaphus valdiviensis* Blanchard, 1851 [now *Achilia valdiviensis* (Blanchard, 1851)] (see Sabella *et al*., 2020: 140, 144-145).
Jeannel (1962: 430) listed *Achilia clavata* Raffray, 1904 as a junior synonym of *A. blanchardi*, but without justifying this action. We have examined the holotype of *A. clavata*, which is a female resembling in all features those of *A. blanchardi*, and therefore we confirm the synonymy proposed by Jeannel.
Jeannel (1962: 430) stated that the type of *Achilia blanchardi* Raffray, 1904 was housed in the MNHN collections. In the MNHN we found in Raffray's collection a series of 11 specimens identified by Raffray as *Achilia blanchardi*; the first specimen of the series is a male labeled "Type / 1880; Chili; Valdivia; leg. Kindermann/ *Bryaxis*; *valdiviensis*; m. Valdivia / Museum de Paris; 1917; coll. Raffray / *A. blanchardi*; A. Raffray det." which we designate here as the lectotype of *A. blanchardi* Raffray, 1904 (Blanchard, 1851), and the remaining 10 specimens (1 male and 9 females) labeled "Chili" without further label data are designated as paralectotypes.
Within the *A. cosmoptera* group the males of *A. blanchardi* are easily distinguished from other species by the shape of the head (Figs 38, 40, 42), antennae (Fig. 17) and aedeagus (Fig. 3). The females of this species are very similar to those of *A. elfridae*, from which they can be distinguished by their wider head with a wider frontal sulcus, and their slightly longer antennomere XI (0.16 mm for *A. blanchard*i vs 0.14-0.15 mm for *A. elfridae*).

Achilia cosmoptera (Blanchard, 1851)
Figs 1, 43, 45, 47, 63

Pselaphus cosmopterus Blanchard, 1851: 563.
Achilia cosmoptera Raffray, 1904: 138; Jeannel, 1962: 426, 428, figs 193 (habitus), 194 (aedeagus); Jeannel, 1963: 353; Jeannel, 1964: 10.
Bryaxis chilensis Reitter, 1883: 49, pl. 1 figs 11 (head and antenna), 12 (palpus), 13 (leg). – Reitter, 1885: 326 (synonymized by Raffray, 1904: 138).
Bryaxis tripunctata Reitter, 1885: 326, 330 (synonymized by Jeannel, 1962: 429).

Type material (2 ex.): MNHN; 1 ♂ (lectotype of *Achilia cosmoptera*, here designated); labels verbatim: "Lectotype / Chile; Gay 1849 / 4 / 40 / *cosmoptera* / Gen. *Achilia* Reitt. = *Bryaxis* aut. Raffray = *Pselaphus* Blanchard / *cosmoptera* Blanch. = *chilensis*; A. Raffray det. 1904". – SOUTHERN CHILE: Región Los Ríos: Valdivia Prov.: MNHN; 1 ♀ (Holotype of *Bryaxis tripunctata*); labels verbatim: "*Bryaxis tripunctata;* m. Valdivia 1880 / Type / *tripunctata* Reitt. (handwritten by Jeannel) / *B. tripunctata*; A. Raffray det. / Museum de Paris; 1917; coll. Raffray".

Additional material examined (83 ex.): HNHM; 1 ♂; "Chili". – MNHN; 8 ♂ and 2 ♀; "Chili" [Valdivia?]. – PCVB; 1 ♂; "Chili". – SOUTHERN AND CENTRAL CHILE: Región Los Lagos: Palena Prov.: PCTS; 1 ♂ and 6 ♀; Homopirén; 41° 87'S 72° 36'W; 17.XII.2013; forest layer. – Chiloé Prov: MHNG; 2 ♂; Chiloé; H. Franz. – NHMW; 1 ♂; Chiloé; H. Franz. – PCVB; 4 ♂; Isla Chiloé, Mocopulli; 04.II.1983; ex *Berberis buxifolia*; T. Cekalovic. – NHMW; 1 ♂ (identified as *A. bifossifrons*); Quinchao Island. – MSNG; 1 ♂; 1 km W of Lago Huillinco; 24.I.1998; site TC-564; T. Cekalovic. – FMNH (FMHD #2002-72); 3 ♂; S side of Huillinco lake, road to Bellavista, 1.3 km S road of Cucao; 42°41.81'S 73° 55.88'W; 45 m; 12-22.XII.2002; valdivian rainforest w/emergent *Saxegothea conspicua*, flight intercept trap; A. Newton, M. Thayer & M. Chani 1062. – MSNG; 1 ♂; Rio Pudeto; 21.II.1989; site SyTC-226; S. & T. Cekalovic. – FMNH; 1 ♂; 2 km N of Puente Pudeto; TC-554; 17.I.1998; Berlese; T. Cekalovic. – FMNH (FMHD #2002-91); 1 ♂ and 2 ♀; Castro, S of Cabañas Trayen; 42° 31'S 73° 48'W; 20.XII.2002; grassy yard on hill, some tres nearby, Berlese, cut grass pile ca. one week old; A. Solodovnikov, M. Chani, A. Newton & M. Thayer. – MSNG; 2 ♂; Chepu; 26.I.2000; site TC-624; T. Cekalovic. – FMNH (FMHD# 97-21); 1 ♂; Puente La Caldera, 9.8 km E of Cucao; 42° 39.96'S 74° 00.70'W; 10 m; 14.I.1997; valdivian rainforest, Berlese, leaf & log litter; A. Newton & M. Thayer 991. – Osorno Prov: MHNG; 1 ♂ and 1 ♀; Puyehue National Park, Aguas Calientes, station 20b; 40° 40'S 72° 20'W; 450-600 m; 01-03.XII.1992; sifting of moss on dead tree trunks, branches and rocks and vegetational debris; D. Burckhardt. – Región Los Ríos, Valdivia Prov: MHNG; 4 ♂; Corral, 39° 95'S 73° 20'W; 06.XII.2013; car net. – MHNG; 4 ♂; Corral, 39° 95'S 73° 20'W; 06.XII.2013; car net. – PCTS; 1 ♂; Caleta Chaihuín, 39° 963'S 73° 586'W; 76.XII.2013; litter layer. – MHNG; 1 ♂; Parque Nacional Alerce Costero, Chaihuín; 0-100 m; 16.II.2018; forest litter; S. Kurbatov. – JEBC; 1 ♂; Chaihuín, Camino a Huaicolla; 39° 59.926'S 73° 38.976W; 107 m; 12.I.2007; fogging *Nothofagus dombeyi*; J. E. Barriga-Tuñón. – JEBC; 5 ♂ and 3 ♀; Chaihuín, Reserva Costiera Valdiviana, en estero; 39° 58.186'S 73° 34.230'W; 30 m; 28.II.2008; J. E. Barriga-Tuñón. – PCVB; 1 ♂ and 1 ♀; Panguipulli. – Región Araucanía: Malleco Prov. – FMNH (FMHD #96-222); 1 ♂; Nahuelbuta National Park, 4.5 km W Los Portones entrance; 37° 49.25'S 72° 59.82'W; 1300 m; 21.XII.1996/07.II.1997; *Nothofagus* spp. emergent *Araucaria araucana, Chusquea* understory, flight intercept trap; A. Newton & M. Thayer 975. – Cautín Prov: NHMW; 1 ♂ (identified as *Achilia approximans*); Rio Pedregoso. – Región Bío Bío: Concepción Prov. – PCVB; 1 ♂; Parque Hualpén;

29.III.1986; site TC-165; T. Cekalovic. – MHNG; 1 ♂; same data; T. Cekalovic. – PCVB; 2 ♂; Concepción; 05.XI.1987; T. Cekalovic. – MHNG; 1 ♂; Periquillo; 21.IX.1996; site TC-486; T. Cekalovic. – MSNG; 1 ♂; same data. – MNHN; 1 ♀; Cerro Caracol; 23.V.1957. – Ñuble Prov.: MNHN; 2 ♂ and 2 ♀; Chillán; P. Germain. – MNHS; 4 ♀ (2 ♀ identified as *A. testacea*); same data. – MHNG; 1 ♂; near Recinto, about 60 km E Chillán; station 7a; 400-450 m; 12.XII.1990; forest litter; M. Agosti & D. Burckhardt. – Región Maule: Cauquenes Prov. – JEBC; 1 ♂ and 2 ♀; Los Ruiles, 20 km W of Cauquenes; 01.X.2003; J. E. Barriga-Tuñón.

Description: Body 1.20-1.40 mm long, dark brown with reddish elytra, generally with darker head and sometimes also darker pronotum, some specimens brown with darker abdomen; antennae and legs reddish; palpi reddish or yellowish.

Male: Head as in Figs 43, 45 & 47, wide, surface with distinct but very scattered fine punctures; occipital region and basal half of frons raised at middle, with flattened and slanting anterior margins; basal half of frons separated by deep transverse sulcus from anterior half of frons, the latter prolonged posteriorly as large median process reaching transverse sulcus and producing median constriction; vertexal foveae lacking. Antennae with scape and pedicel longer than wide; antennomeres III-VI longer than wide; antennomere VII about as long as wide; antennomere VIII slightly wider than long; antennomere IX slightly wider than VIII and wider than long; antennomere X distinctly wider than long and wider than IX; antennomere XI elongate, about as long as VII-X combined. Metaventrite with deep and wide transverse sulcus on apical two-thirds, sulcus with prominent margins. First abdominal sternite slightly raised and flattened at middle; remaining abdominal sternites slightly flattened at middle. Protibiae with distal two-thirds swollen, distal third densely pubescent; mesotibiae with small subapical spur on medial margin, distal half swollen and densely pubescent. Aedeagus (Fig. 1) 0.20-0.21 mm long, with suboval dorsal plate distinctly narrower apically; dorsal longitudinal struts divergent. Parameres relatively wide with very large and long recurved seta on well-developed outer lobe; apical portion of parameres slightly recurved posteriorly, prolonged laterally as short tip; apex bearing one ventral medial seta. Copulatory pieces consisting of two subequal pointed sclerites recurved at both ends and more robust basally.

Female: Similar to male except head not modified. Antennae shorter with antennomere XI much shorter; metaventrite, abdominal sternites, and legs unmodified.

Collecting data: Collected from September to March, in different types of forests (i.e. *Berberis buxifolia*; Valdivian rainforest with *Saxegothea conspicua; Nothofagus* spp. forest sometimes with *Araucaria araucana* and *Chusquea*) at elevations ranging from 0 m to 1300 m. Most specimens come from sifted samples of leaf and log litter, sometimes with moss and vegetational debris, and males have also been collected by flight intercept traps, window traps, and car netting.

Distribution: *Achilia cosmoptera* is distributed in Southern and Central Chile (Fig. 63: red square) from Palena Province to Cauquenes Province. Jeannel (1962: 429) mentions that this species occurs in Valdivia based on 8 males and 2 females, which probably refers to the specimens we identified as such from the Raffray collection labeled "Chili" without further label data.
Jeannel mentions the presence of specimens of *A. cosmoptera* from Nahuelbuta (1963: 353, 1 ♀ collected by F. Castri in 14.XII.1961) and Tiltil (1964:10-11, 1 ♀ collected by F. Castri in VIII.1962), that appear to be based on two misidentified females of *A. testacea*.

Comments: Blanchard described *Pselaphus cosmopterus* (1851: 563) based on an unspecified number of specimens from San Cárlos (Region Bío Bío, Ñuble Province). The description was so imprecise that subsequent authors (Reitter, 1885; Schaufuss, 1886; and Raffray, 1895) thought the species belonged in the Tyrini.
Reitter (1883: 50) described *Bryaxis chilensis* based on an unspecified number of specimens from Valdivia. Raffray (1904: 138), having studied the type of *Pselaphus cosmopterus* Blanchard, 1851, which he mentions as being housed in the MNHN collections, established that this species was not a member of Tyrini and should be transferred to *Achilia* in the Brachyglutini, pointing out that *Bryaxis chilensis* Reitter, 1883 was the same taxon as *Achilia cosmoptera* (Blanchard, 1851).
Jeannel (1962: 429) claimed that *Bryaxis tripunctata* Reitter, 1885, which was described based on one single female from Valdivia, was indeed a female of *A. cosmoptera* but was darker and had a small pit on the head vertex. These characters are apparently variable within this species.
Jeannel (1962: 428) affirmed that the types of *Achilia cosmoptera* (Blanchard, 1851), *Bryaxis chilensis* Reitter, 1883, and *Bryaxis tripunctata* Reitter, 1885 were present in the MNHN collections. In the MNHN we found in the Raffray collection the holotype female of *Bryaxis tripunctata* Reitter, 1885. We also found 8 females (the first bearing a red label Type) and 2 males with the label locality "Chili" without further data, identified by Raffray as *A. cosmoptera*, these ten specimens could well represent the type series of *B. chilensis* Reitter, 1883, or possibly part of it. Finally, we found in the general collection 1 male labeled "Chile; Gay 1849/ 4 / 40 / *cosmoptera* / Gen. *Achilia* Reitt. =; *Bryaxis* aut. Raffray =; / *Pselaphus* Blanchard / *cosmoptera* Blanch. =; *chilensis*; A. Raffray det. 1904". We think that this male, which was collected by Gay and studied by Raffray, belongs to the type series of *Achilia cosmoptera* (Blanchard, 1851), and therefore we designate it as the lectotype of *Pselaphus cosmopterus* Blanchard, 1851.
The males of *A. cosmoptera* are easily distinguished from other species of the *A. cosmoptera* group by the shape of the head (Figs 43, 45, 47), and aedeagus (Fig. 1).

The females of this species are very similar to those of *A. elfridae*, from which they can be distinguished by their more convex frons, smaller vertexal foveae, and narrower frontal sulcus.

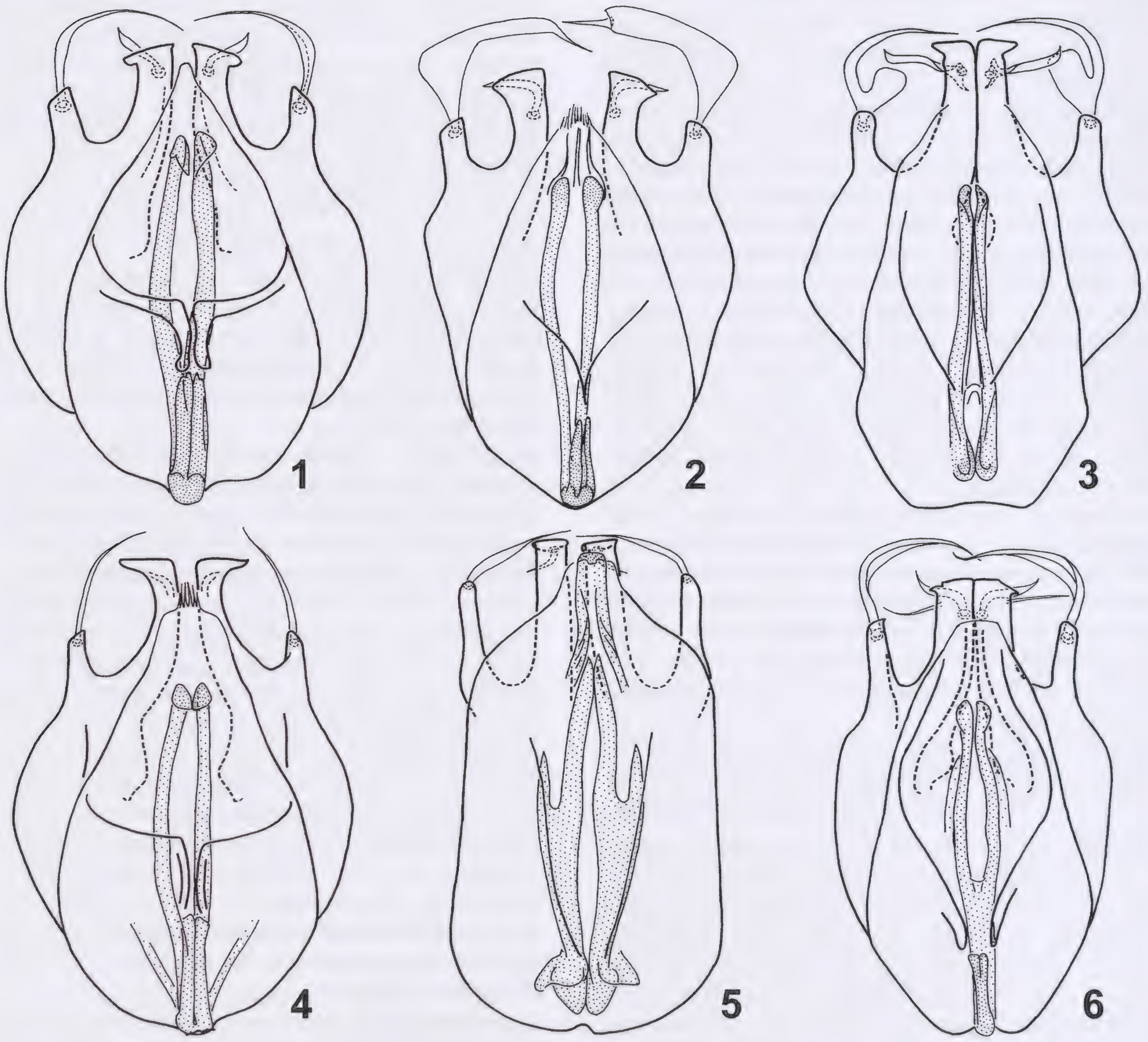
Achilia covidia n. sp.

Figs 2, 16, 26, 44, 46, 48, 63

Holotype: MHNG (# MHNG-ENTO-85480); 1 ♂; SOUTHERN CHILE: Región Los Lagos: Osorno Prov.: Puyehue National Park, Antillanca road; 500-1000 m; 18-20. XII.1984; car netting; S. & J. Peck.

Description: Body 1.15 mm long, dark with dark reddish elytra, antennae, legs, and palpi.

Male: Head as in Figs 44, 46 & 48, wide. Occipital region and median part of frons raised; frons flattened laterally and confluent with deep and large transverse sulcus delimiting it from frontal lobe; anterior part of frontal lobe prolonged posteriorly as short median process; sides of frons slightly sharp; surface of frontal lobe with sparse punctures. Antennae (Fig. 16) with scape distinctly longer than wide; pedicel slightly longer than wide; antennomeres III and V about as long as wide; antennomeres IV and VI-VII slightly wider than long; antennomere VIII wider than long; antennomere IX wider than VIII and distinctly wider than long; antennomere X distinctly wider than long and wider than IX; antennomere XI elongate, longer than VII-X combined. Metaventrite with deep and wide medial semioval impression on apical half, impression sparsely pubescent and punctate. Protibiae with distal half slightly swollen; mesotibiae (Fig. 26) with two small subapical spurs on medial margin, distal half swollen and densely pubescent; metatibiae with distal half slightly arcuate. Aedeagus (Fig. 2) 0.21 mm long, with suboval dorsal plate distinctly narrowed and frayed apically; dorsal longitudinal struts divergent. Parameres



Figs 1-6. Aedeagi of *Achilia*. (1) *A. cosmoptera*. (2) *A. covidia*. (3) *A. blanchardi*. (4) *A. elfridae*. (5) *A. bifrons*. (6) *A. temporalis*.

relatively wide with very large and long recurved seta on well-developed outer lobe; apical portion of parameres prolonged laterally as short tip; apex bearing one ventral long medial seta. Copulatory pieces consisting of a pair of subequal sclerites that are rounded apically, recurved and more robust basally.
Female: Unknown.

Collecting data: The only specimen was collected in December by car netting at an elevation of 500-1000 meters.

Distribution: *Achilia covidia* n. sp. is only known from Puyehue National Park (Región Los Lagos: Osorno prov.) (Fig. 63: blue triangles).

Comments: The males of *A. covidia* n. sp. are easily distinguished from other species of the *A. cosmoptera* group by the shape of the head (Figs 44, 46, 48), antennae (Fig. 16), and aedeagus (Fig. 2).

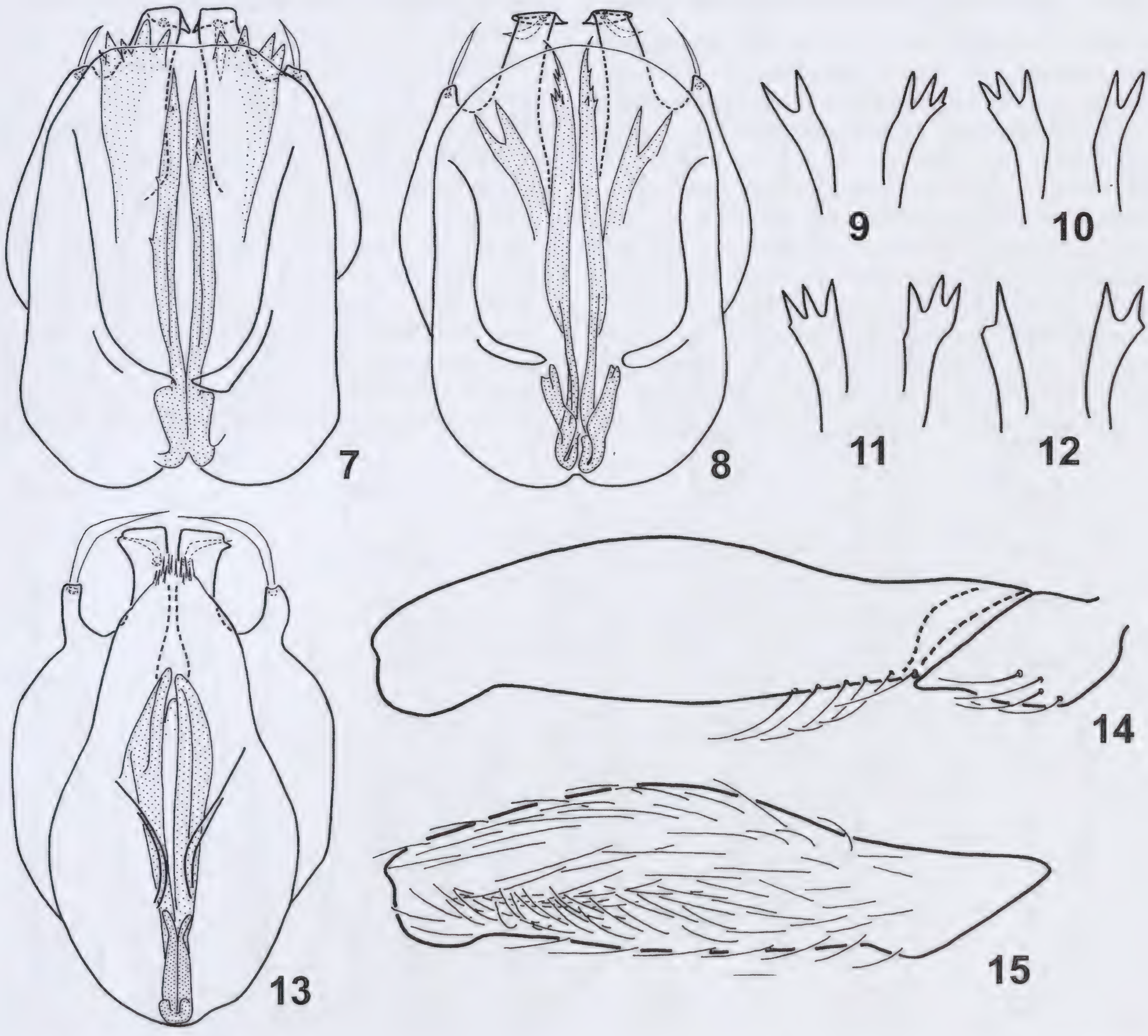
Etymology: The epithet of this new species refers to the COVID-19 pandemic and the periods of quarantine during which this study was carried out by the authors.

Achilia elfridae Raffray, 1904

Figs 4, 23, 28, 49-51, 53, 55, 64

Achilia elfridae Raffray, 1904: 139, fig. 54 (head and antenna of male). – Jeannel, 1962: 426, figs 190 (head), 191 (aedeagus).
Achilia picea Raffray, 1904: 139. – Jeannel, 1962: 426-427 (**syn. nov.**).

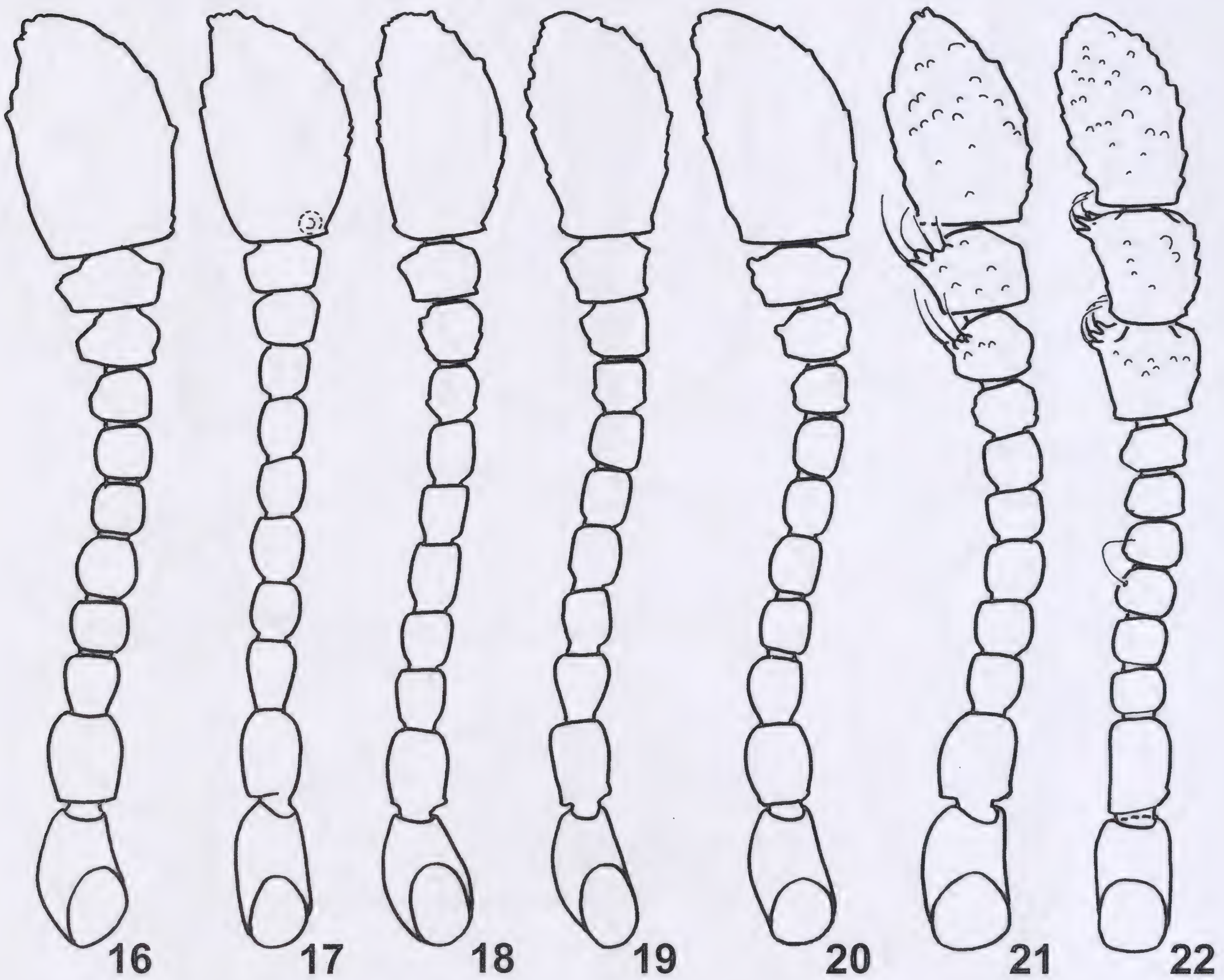
Type material (7 ex.): SOUTHERN CHILE: Región Los Ríos: Valdivia Prov.: MNHN; 1 ♂ (lectotype of *A. elfridae*, here



Figs 7-15. Aedeagi (7, 8, 13), their internal sacs (9-12), and profemora (14, 15) of *Achilia*. (7, 14) *A. quarantena*. (8-12, 15) *A. angularis*, specimens from Malleco, Nahuelbuta National Park. (10) *A. angularis*, type from Chillan. (13) *A. pandemica*.

designated); labels verbatim "Lectotype / Type / *Bryaxis elfridae* m.; Valdivia / Museum Paris; 1917; coll. Raffray / *A. elfridae*; A. Raffray det.". – MNHN; 3 ♂ and 2 ♀ (Paralectotypes of *A. elfridae*, here designated); labels verbatim "Paralectotype / Chili". – MNHN; 1 ♀ (holotype of *Achilia picea*); labels verbatim "Type/ Valdivia, var. *valdiviensis*; / Museum Paris; 1917; coll. Raffray/ *A. picea*; A. Raffray det. / *picea* Raff. (handwritten by Jeannel)".

Additional material examined (67 ex.): SOUTHERN ARGENTINA: Rio Negro Prov.: MHNG; 1 ♂; El Bolsón, Topal, n. 51; 06.II.1961. – SOUTHERN AND CENTRAL CHILE: Región Los Lagos: Llanquihue Prov.: MHNG; 28 ♂; Frutillar Bajo, Universidad Chile Forest Reserve; 100 m; 22.XII.1984/02.II.1985; FIT, ravine mixed forest; S. & J. Peck. – Chiloé Prov.: MSNG; 1 ♂; Piruquina; 22.II.1991; site TC-280; T. Cekalovic. – Región Los Ríos: Valdivia Prov.: PCTS; 1 ♂; Corral, 39° 95"S 73° 20"W; 06.XII.2013; car net. – PCVB; 1 ♂ and 1 ♀; Panguipulli. – FMNH (FMHD #97-18); 2 ♂; Rincón de La Piedra, turnoff, 14.8 km SE Valdivia; 39° 55' 32"S 73° 06' 27"W; 50 m; 11.I-01.II.1997; disturbed Valdivian rainforest, with *Nothofagus dombeyi* and *Podocarpus saligna*, flight intercept (windows) trap; A. Newton & M. Thayer 990. – Región Araucanía: Cautín Prov.: UNHC; 1 ♂; Volcàn Villarica; 1120 m; site 654; 15-29.XII.1982; *Nothofagus dombeyi* and *Saxegothea* forest with *Drimys*, flight intercept (windows) trap; A. Newton & M. Thayer. – Malleco Prov.: MHNG; 1 ♂; Purén, Contulmo Natural Monument; station 17; 350 m; 11.XII.1984; S. & J. Peck. – MHNG; 2 ♂; same locality; 11.XII.1984-13. II.1985; S. & J. Peck 85-16. – MHNG; 3 ♂; same locality; 13.II.1985; mixed forest litter; S. & J. Peck. – MHNG; 1 ♂; 40 km W CuraCautín; 1500 m, 12.XII.1984/16.II.1985; *Notophagus* and *Araucaria* forest, malaise trap; S. & J. Peck. – FMNH (FMHD #85-905, #85-19); 1 ♂; Curaracautín (40 km E); 1500 m; 12.XII.1984/16.II.1985; *Nothofagus-Araucaria* forest, malaise trap; S. & J. Peck #85-19. – MHNG; 1 ♂; E Malalcahuello, 38° 26,0'S 71° 30,2'W; 1200 m; 11.II.2018; litter near stream; S. Kurbatov. – FMNH (FMHD #2002-041); 2 ♂; Nahuelbuta National Park, E of Guarderia Pichinahuel; 37° 48.20'S 73° 01.41'W; 1290 m; 05-24.XII.2002; *Araucaria-Nothofagus dombeyi* with *Chusquea* bamboo, flight intercept trap; A. Newton, M. Thayer, A. Solodovnikov; D. J. Clarke & M. Chani 1054. – Región Bío Bío: Ñuble Prov.: MNHN; 3 ♂ and 7 ♀; Chillàn. – MNHS; 4 ♂ and 5 ♀; Chillàn; P. Germain.



Figs 16-22. Male antennae of *Achilia*. (16) *A. covidia*. (17) *A. blanchardi*. (18) *A. bifrons*. (19) *A. temporalis*. (20) *A. pandemica*. (21) *A. angularis*. (22) *A. quarantena*.

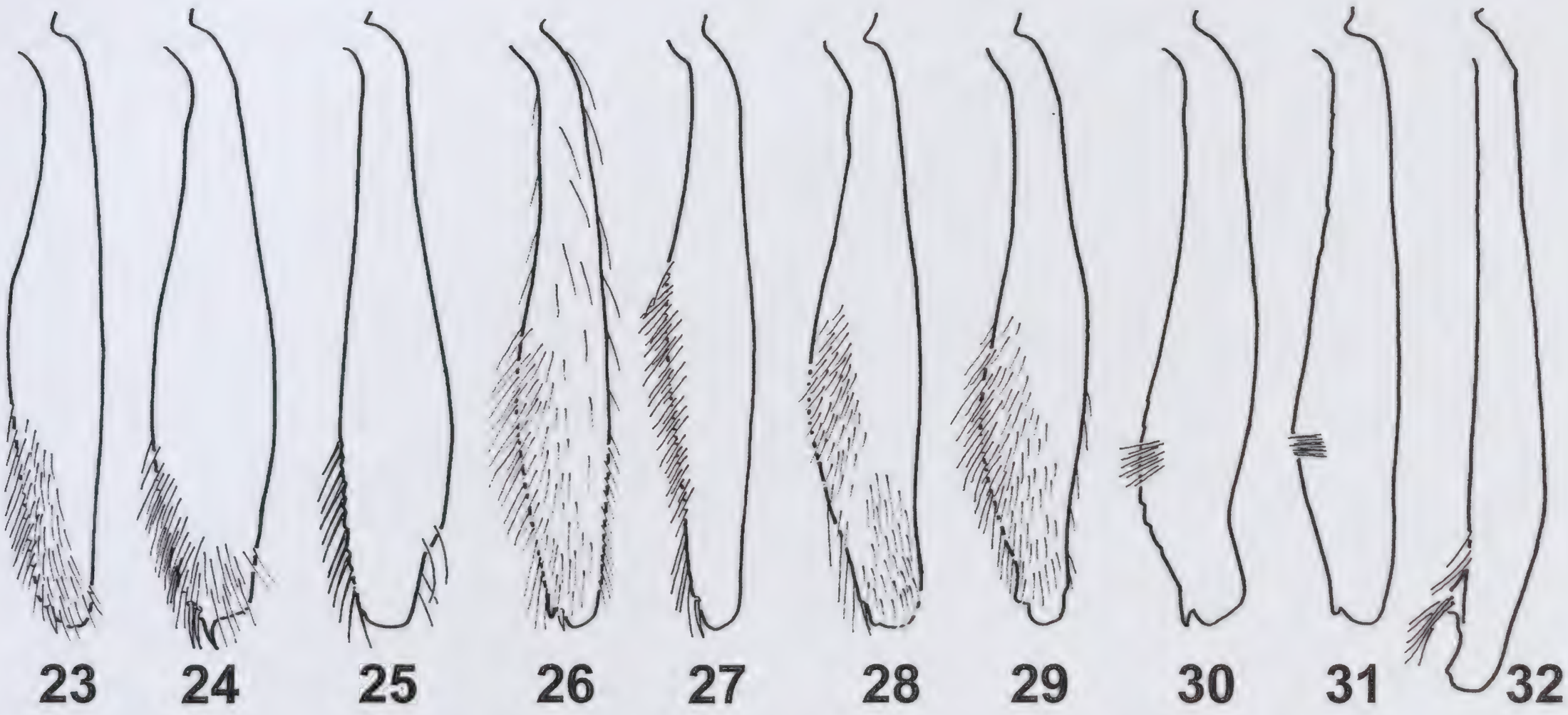
– Región Maule: Curicó Prov.: MHNG; 1 ♂; 30 km SE Curicó; 35° 13.3'S 70° 59.3'W; 200 m; 08.II.2018; litter near stream; S. Kurbatov.

Description: Body 1.25-1.35 mm long, brown with reddish elytra, generally with darker head and sometimes also darker pronotum, some specimens brown with darker abdomen; antennae and legs reddish; palpi reddish or yellowish.
Male: Head as in Figs 51, 53, 55, wide, with occipital region slightly raised; frons flattened with enlarged and carinate sides on anterior half, and shallow triangular impression at middle; frons separated from enlarged frontal lobe by wide transverse sulcus. Antennae with scape and pedicel longer than wide; antennomere III longer than wide; remaining funicular articles slightly varying from antennomeres IV-VII slightly longer than wide to distinctly longer than wide and thinner, and from antennomere VIII wider than long to as long as wide; antennomere IX slightly wider than VIII and wider than long; antennomere X wider than long, and slightly wider than IX; antennomere XI elongate, about as long as VII-X combined. Metaventrite with deep and wide transverse sulcus on apical two-thirds, sulcus with prominent margins. First abdominal sternite slightly raised and flattened at middle (Fig. 50); remaining abdominal sternites distinctly flattened at middle. Protibiae (Fig. 23) with distal half swollen, distal third densely pubescent; mesotibiae (Fig. 28) with distal half swollen and densely pubescent. Aedeagus (Fig. 4) 0.24-0.26 mm long, with suboval dorsal plate narrowed and frayed at apex; dorsal longitudinal struts divergent. Parameres relatively wide with long recurved seta on well-developed outer lobe; apical portion of parameres prolonged laterally as long tip; apex bearing ventral medial seta. Copulatory pieces consisting of pair of subequal sclerites curved at both ends and more robust basally.
Female: Similar to male except head not modified; antennae shorter with antennomere XI shorter; metaventrite, abdominal sternites, and legs unmodified.

Collecting data: Collected from November to February in different type of forests (mixed forest, disturbed Valdivian rainforest, *Nothofagus dombeyi* and *Saxegothea* forest with *Drimys*, *Nothophagus* and *Araucaria* forest, *Araucaria-Nothofagus dombeyi* with *Chusquea* bamboo), at elevations ranging from 50 m to 1290 m. Some specimens come from sifted samples of leaf and log litter, but most males have been collected by flight intercept traps, window traps, car netting, and malaise traps.

Distribution: *Achilia elfridae* is distributed in Southern Argentina (Rio Negro Province) and Southern and Central Chile (from Llanquihue to Curicó Provinces) (Fig. 64: red circles).

Comments: Raffray (1904: 139) described *A. elfridae* based on an unspecified number of specimens from Chile, without further indication of locality, claiming to use the unpublished name attributed by Reitter to the specimens in his collection (now in Raffray's collection). Jeannel (1962: 426-427) affirmed that the type of *Achilia elfridae* Raffray, 1904 collected in Valdivia was housed in the MNHN collections. In the MNHN we found in the Raffray collection a series of 6 specimens identified by Raffray as *Achilia elfridae*; the first specimen is a male labeled "Type / *Bryaxis elfridae* m.; Valdivia / Museum Paris; 1917; coll. Raffray / *A. elfridae*; A. Raffray det." that we designate here as the lectotype of *Achilia elfridae* Raffray, 1904, and the



Figs 23-32. Male protibiae (23-25), mesotibiae (26-31) and metatibiae (32) of *Achilia*. (23, 28) *A. elfridae*. (24, 30, 32) *A. angularis*. (25, 31) *A. quarantena*. (26) *A. covidia*. (27) *A. blanchardi*. (29) *A. pandemica*.

remaining 5 specimens (4 males and 1 female) labeled "Chili" without further label data are designated as paralectotypes.

Raffray (1904: 136) described *Achilia picea* on the basis of one female that Reitter had in his collection (now in Raffray's collection) and placed it as a variety of *Bryaxis valdiviensis* Reitter, 1883 (= *Achilia blanchardi* Raffray, 1904). According to Raffray (1904: 136) *A. picea* differs from *A. blanchardi* by having a longer head, thinner antennae, longer elytrae with denser punctures, and a darker body color. According to Jeannel (1962: 427) *A. picea* strongly resembles the females of *A. elfridae*, from which it differs only by the darker coloration, the more transverse pronotum, and the narrower lateral bulges of the frontal lobe. We examined the holotype and only known specimen of *A. picea*; it is a female which indeed has a darker body color, but is otherwise similar in all other aspects to the females of *A. elfridae*, and therefore we here place *A. picea* Raffray, 1904 as a junior synonym of *A. elfridae* Raffray, 1904 (**syn. nov.**).

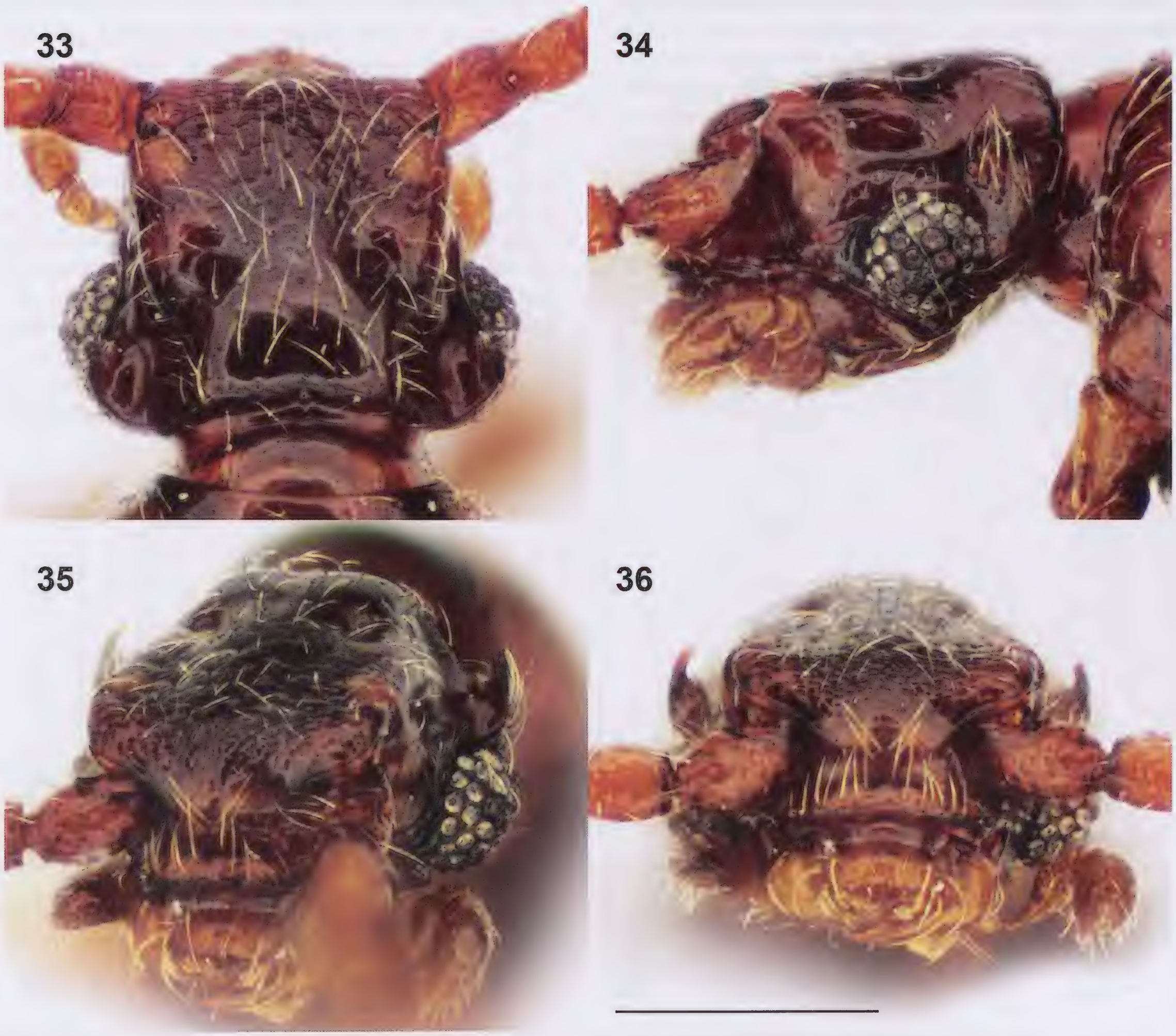
The males of *A. elfridae* are easily distinguished from other species of the *A. cosmoptera* group by the shape of the head (Figs 51, 53, 55), and aedeagus (Fig. 4). For characters to distinguish the females of *A. elfridae* from those of *A. cosmoptera* and *A. blanchardi* see the "Comments" section for the two latter species.

Achilia melanocephala Jeannel, 1963

Fig. 64

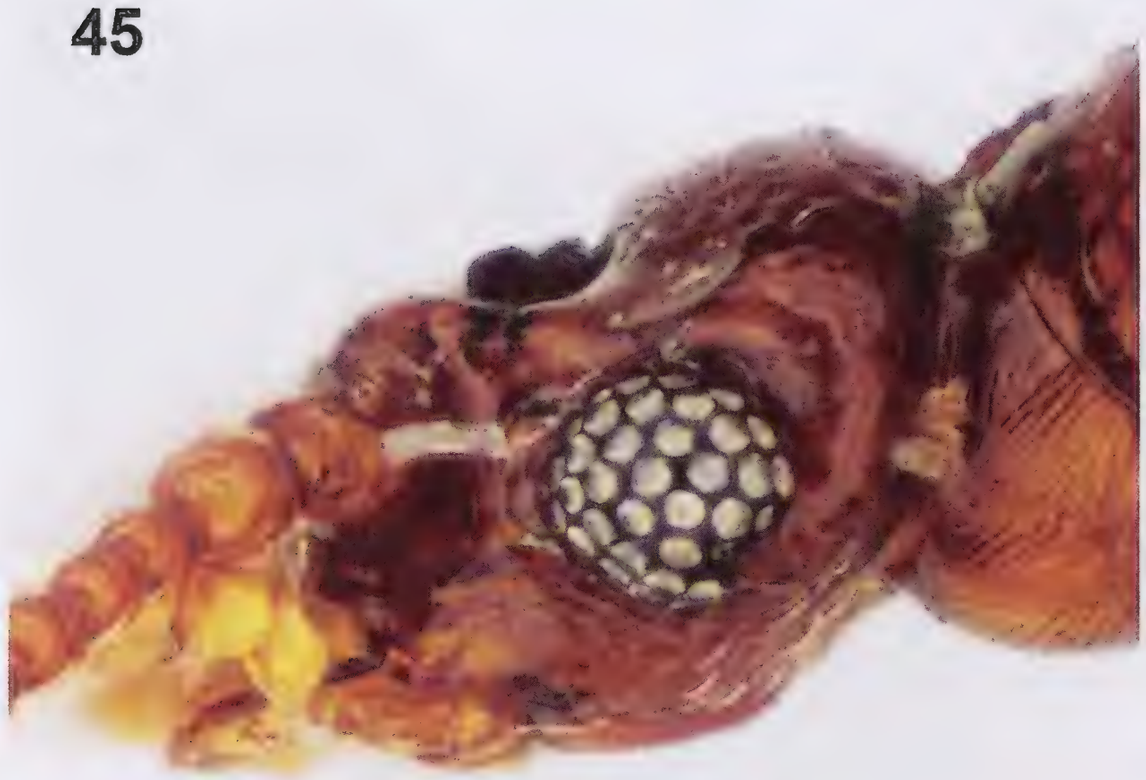
Achilia melanocephala Jeannel, 1963: 353, 367.

Type material (1 ex.): CENTRAL CHILE: Región O'Higgins: Cachapoal Prov.: MNHN; 1 ♀ (holotype); labels verbatim "Holotype / Palmas de Cocálan / *Achillia melanocephala* nov. (handwritten by Jeannel)".



Figs 33-36. *Achilia angularis*. Male head in (33) dorsal, (34) lateral, (35) semifrontal, and (36) frontal views. Scale bar = 200 μm.

Figs 37-42. (37, 39, 41) *Achilia bifrons*. (38, 40, 42) *A. blanchardi*. Male head in (37-38) dorsal, (39-40) lateral and (41-42) frontal views. Scale bars (200 µm) left for (37, 39, 41) and right for (38, 40, 42).



Figs 43-48. (43, 45, 47) *Achilia cosmoptera*. (44, 46, 48) *A. covidia* n. sp. Male head in (43-44) dorsal, (45-46) lateral and (47-48) frontal views. Scale bars (200 μm) left for (43, 45, 47) and right for (44, 46, 48).

Description: *Male*: Unknown.
Female: Body 1.40 mm long, reddish brown with darkened head and abdomen; antennae and legs reddish; palpi yellowish. Head with frons and occipital region slightly convex; frontal lobe short, separated from frons by shallow transverse sulcus. Antennae with scape and pedicel slightly longer than wide; antennomeres III-VIII wider than long; antennomere IX wider than VIII, distinctly wider than long; antennomere X wider than IX, distinctly wider than long; antennomere XI moderately elongate, shorter than VII-X combined.

Collecting data: No data available.

Distribution: *Achilia melanocephala* is only known from Cachapoal Province (Región O'Higgins) (Fig. 64: triangles edged in blue).

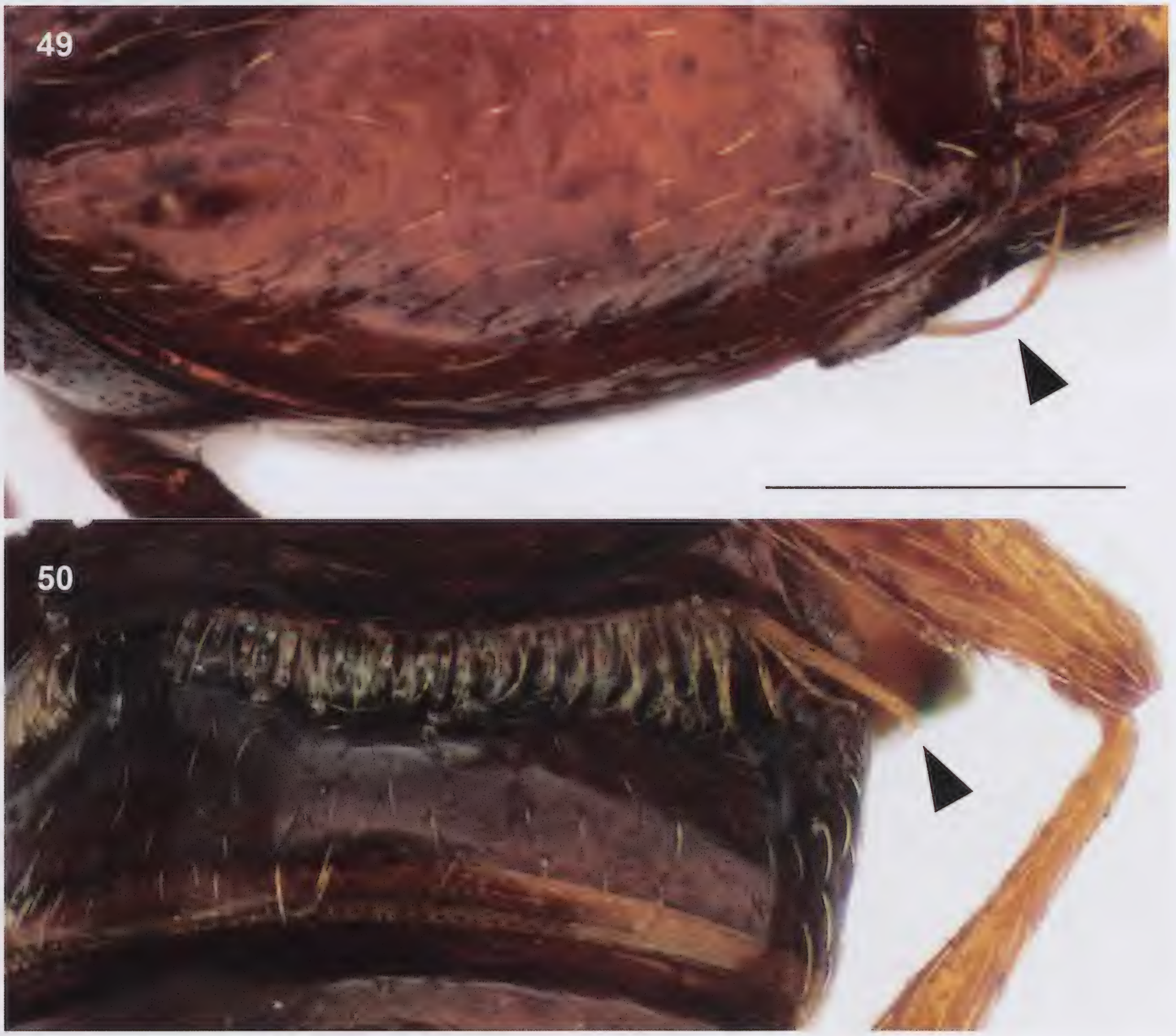
Comments: The holotype of *A. melanocephala* is a female very similar to those of *A. angularis*. However, since it was collected in a region quite distant from where *A. angularis* is known, we prefer at present to maintain *A. melanocephala* as a valid species. Its status should be reassessed once additional specimens, notably males, are available from or near the type locality.

Achilia pandemica n. sp.

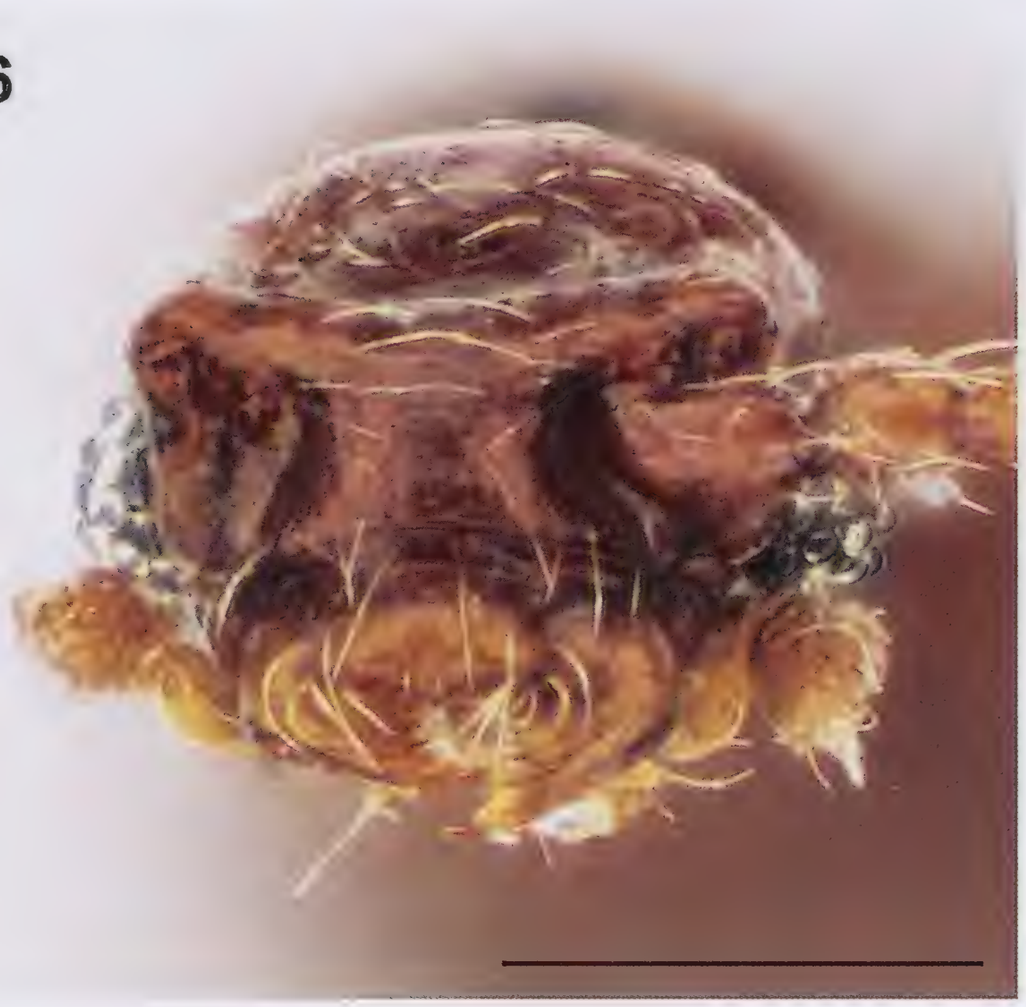
Figs 13, 20, 29, 52, 54, 56, 64

Holotype: MHNG (# MHNG-ENTO-85483); 1 ♂; CENTRAL CHILE: Región Bío Bío: Concepción Prov.: Periquillo; 21.IX.1996; site TC-486; T. Cekalovic.

Paratypes (318 ex.): CENTRAL CHILE: Región Bío Bío: Concepción Prov.: NHMW; 4 ♂ and 18 ♀ (identified as



Figs 49-50. *Achilia elfridae*. Left elytra and basal abdominal segment head in semilateral view (49) and left portion of basal abdominal sternites in ventral view (50). Arrows indicate bundle of long setae on lateral side of first visible abdominal sternite. Scale bar = 200 μm.



Figs 51-56. (51, 53, 55) *Achilia elfridae*. (52, 54, 56) *A. pandemica* n. sp. Male head in (51-52) dorsal, (53-54) lateral and (55-56) frontal views. Scale bars (200 μm) left for (51, 53, 55) and right for (52, 54, 56).

Figs 57-62. (57, 59, 61) *Achilia quanrantena* n. sp. (58, 60, 62) *A. temporalis.* Male head in (57-58) dorsal, (59-60) lateral and (61-62) frontal views. Scale bars (200 µm) left for (57, 59, 61) and right for (58, 60, 62).

A. bifrons); Periquillo; 24.X.1992. – NHMW 12 ♀ (identified as *A. tumidifrons*); Periquillo; 24.IX.1993. – FMNH; 1 ♀; Periquillo; 10.V.1997; site TC-549; T. Cekalovic. – MSNG; 2 ♂ and 44 ♀; Periquillo; 15.IX.1992; site TC-311; T. Cekalovic. – MHNG (# MHNG-ENTO-85484 through 85488); 1 ♂ and 4 ♀; same data as previous. – MSNG; 1 ♂ and 24 ♀; Periquillo; 30.I.1997; site TC-516; T. Cekalovic. – MHNG (# MHNG-ENTO-85489 through 85491); 3 ♀; same data. – MSNG; 2 ♀; Periquillo; 01.IV.1997; site TC-541b; T. Cekalovic. – MHNG (# MHNG-ENTO-85492); 1 ♀; same data. – MSNG; 1 ♂ and 55 ♀; Periquillo; 16.IX.1996; site TC-485; T. Cekalovic. – MHNG (# MHNG-ENTO-85493 through 85495); 3 ♀; same data. – PHPC; 2 ♀; same data. – MHNS; 2 ♀; same data. – MSNG; 27 ♂ and 40 ♀; Periquillo; 21.IX.1996; site TC-486; T. Cekalovic. – MHNG (# MHNG-ENTO-85496 through 85508); 7 ♂ and 6 ♀; same data. – MHNS; 2 ♂ and 2 ♀; same data. – MSNG; 35 ♀; Camino a Hualqui; 17.X.1992; T. Cekalovic. – MHNG (# MHNG-ENTO-85509 through 85512); 4 ♀; same data. – UNHC; 1 ♂; Pinares; 21.X.1977; Acc.Z# 16-683; H. S. Steeves. – PHPC; 1 ♂; Chaimavida, Estero Agua de la Gloria; 14.VIII.1978; site TC-83; T. Cekalovic. – Región Maule: Curicó Prov.: JEBC; 11 ♂; Cerro HuecaHuecan, 15 km E Curicó; 35° 3.97'S 71° 7.45'W; 300 m; 20.II-07.III.2008; luz mercurio, J. E. Barriga-Tuñón. – MHNG (# MHNG-ENTO-85513 through 85514); 2 ♂; same data.

Description: Body 1.45-1.65 mm long, entirely reddish, some specimens with slightly darkened abdomen; palpi yellowish.

Male: Head as in Figs 52, 54 & 56, wide, with slightly raised occipital region and frons; frons flattened laterally with sharp and subparallel sides, separated from frontal lobe by deep and flatten narrowed transverse sulcus. Antennae (Fig. 20) with scape distinctly longer than wide; pedicel and antennomere III slightly longer than wide; antennomere IV about as long as wide; antennomeres V-VII longer than wide; antennomere VIII slightly wider than long; antennomere IX wider than VIII and wider than long; antennomere X distinctly wider than long and wider than IX; antennomere XI elongate, about as long as VII-X combined. Metaventrite with apical portion crossed on two thirds by deep and wide medial suboval impression, impression with prominent margins. First abdominal sternite slightly raised and flattened at middle; remaining abdominal sternites flattened at middle. Mesotibiae (Fig. 29) with distal half swollen and densely pubescent, with stout subapical mesal spine. Aedeagus (Fig. 13) 0.25-0.26 mm long, with ovoidal dorsal plate narrowed and frayed at apex; dorsal longitudinal struts slightly divergent. Parameres relatively wide with large and long recurved seta on well-developed outer lobe; apical portion of parameres slightly enlarged and prolonged laterally as short spine;

Fig. 63. Distribution map of the *Achilia cosmoptera* species group. (▼ blue inverted triangles) *A. bifrons*. (◆ green diamonds) *A. blanchardi*. (■ red square) *A. cosmoptera*. (▲ blue triangles) *A. covidia* n. sp.

apex bearing one ventral median seta. Copulatory pieces consisting of a pair of short subequal lateral sclerites recurved and more robust basally.
Female: similar to male except head not modified; antennae shorter; eyes smaller; metaventrite with shallow and narrow medial sulcus; abdominal sternites, and legs unmodified.

Collecting data: The label data indicate a very long collecting period from August to April.

Distribution: *Achilia pandemica* n. sp. occurs in Central Chile (Región Bío Bío and Región Maule) from Concepción to Curicó Provinces (Fig. 64: circles edged in green).

Comments: The males of *A. pandemica* n. sp. are easily distinguished from other species of the *A. cosmoptera* group by the shape of the head (Figs 52, 54, 56), and antennae (Fig. 20). The aedeagus is very similar to that of *A. temporalis*, but the shape of the parameres is distinctive. The females of *A. pandemica* n. sp. are similar to those of *A. temporalis*, from which they can be distinguished by their narrower head with the frons slightly convex and flattened anteromedially (distinctly convex and not flattened in *A. temporalis*), and mostly by the lateral margins of the frons being subparallel and acute with very prominent antennal tubercles (sides of frons slightly convergent, blunt and with antennal tubercles not prominent in *A. temporalis*).

Etymology: The epithet of this new species refers to the COVID-19 pandemic and the periods of quarantine during which this study was carried out by the authors.

Achilia quarantena n. sp.

Figs 7, 14, 22, 25, 31, 57, 59, 61, 64

Holotype: MHNG (# MHNG-ENTO-85515); 1 ♂; CENTRAL CHILE: Región Bío Bío: Ñuble Prov.: 72 km SE Chillán, Trancas, near Termas; 1700 m; 06.XII.1984; *Nothofagus* forest litter, Berlese; S. & J. Peck.

Paratypes (45 ex.): CENTRAL CHILE: Región Bío Bío: Ñuble Prov.: MHNG (# MHNG-ENTO-85516 through 85524); 5 ♂ and 4 ♀; 72 km SE Chillán, Trancas, near Termas; 1700 m; 06.XII.1984; *Nothofagus* forest litter, Berlese; S. & J. Peck. – FMNH; 1 ♂ and 1 ♀; Las Trancas, 19.5 km ESE Recinto; 1250 m; site 647; 10.XII.1982/03.I.1983; *Nothofagus* forest,

Fig. 64. Distribution map of *Achilia cosmoptera* group. (■ squares edged in blue) *A. angularis*. (● red circles) *A. elfridae*. (△ triangles edged in blue) *A. melanocephala*. (○ circles edged in green) *A. pandemica*. (★ fuchsia stars) *A. quarantena* n. sp. (■ green squares) *A. temporalis*.

flight intercept (windows) trap; A. Newton & M. Thayer. – FMNH; 1 ♀; same data but Berlese, leaf & log litter, forest floor. – FMNH (FMHD #54-65); 1 ♂; Refugio Andino, Volcán Chillán; Las Trancas; I.1954; *Nothofagus* forest; L. E. Peña. – FMNH; 2 ♂; Las Cabras, Cordillera de Chillán; 19-29.I.1955; L. E. Peña. – UHNC; 2 ♂ and 3 ♀; 22.7 km ESE Recinto; 1330 m; site 646; 10.XII.1982/03.I.1983; *Nothofagus* forest, window trap; A. Newton & M. Thayer. – FMNH; 1 ♂; same data. – FMNH; 1 ♂ and 2 ♀; same data but Berlese, leaf & log litter, forest floor. – MNHS; 1 ♂ and 1 ♀; same data. – FMNH; 14 ♀; same data but Berlese, leaf & log litter, forest floor, vouchers associated with larvae. – MHNG (# MHNG-ENTO-85525 through 85527); 3 ♀; same data. – MNHS; 2 ♀; same data.

Description: Body 1.45-1.60 mm long, reddish brown with darkened head and abdomen; antennae and legs reddish; palpi yellowish.

Male: Head as in Figs 57, 59 & 61, subrectangular with slightly convex occipital region and frons, lateral portion of the latter slightly flattened; frons and frontal lobe punctate, both separated by shallow transverse sulcus; temporal angles prolonged in long spiniform process directed upwards. Antennae (Fig. 22) with scape and pedicel distinctly longer than wide; antennomeres III-VIII wider than long; antennomere IX wider than VIII, slightly wider than long; antennomere X about as wide as IX, longer than wide; antennomeres IX and X bearing some tubercles, their mediodistal margin with three prominent tubercles each bearing thin recurved seta; antennomere XI moderately elongate, shorter than IX-X combined, its surface bearing some tubercles. Metaventrite with very shallow ovoidal medial impression on basal third. Profemora (Fig. 14) enlarged with some long seta on ventral margin; protibiae (Fig. 25) with distal third swollen and densely pubescent; mesotibiae (Fig. 31) with distal half slightly swollen and ending as very short apical spine, with group of dense short setae on basal third of medial margin; metatibiae sinuate and slightly arcuate on basal half. Aedeagus (Fig. 7) 0.22-0.23 mm long, with subrectangular dorsal plate; dorsal longitudinal struts divergent. Parameres relatively wide with one seta on very short outer lobe; apical portion of parameres recurved backwards, bearing one ventral median seta. Copulatory pieces consisting of two subequal sclerites recurved, more robust at base, and apically pointed; these sclerites associated with two large lateral sclerites apically forming four or five spines.

Female: Similar to male except head not modified; antennae shorter with unmodified club; eyes smaller; metaventrite slightly flattened near posterior margin; legs unmodified.

Collecting data: Collected from December to January in *Nothofagus* forest at elevations ranging from 1200 m to 1700 m. The specimens come from sifted samples of leaf and log litter, but many males have also been collected by flight intercept and window traps.

Distribution: *Achilia quarantena* n. sp. is known from Central Chile from the Bío Bío Región in Ñuble Province (Fig. 64: fuchsia stars).

Comments: The males of *A. quarantena* n. sp. are easily distinguished from other species of the *A. cosmoptera* group by the shape of the head (Figs 57, 59, 61), the peculiar morphology of the antennae (Fig. 22) and aedeagus (Fig. 7). Females of *A. quarantena* n. sp. are similar to those of *A. angularis*, from which they can be distinguished by the convergent anterior sides of the head (subparallel in *A. angularis*), the flattened frons and occipital region (slightly convex for *A. angularis*), and the antennae distinctly longer (0.34-0.35 mm for *A. quarantena* vs. 0.30-0.31 mm for *A. angularis*).

Etymology: The epithet of this new species refers to the COVID-19 pandemic and the periods of quarantine during which this study was carried out by the authors.

Achilia temporalis Jeannel, 1962

Figs 6, 19, 58, 60, 62, 64

Achilia temporalis Jeannel ,1962: 426, 427, fig. 200 (aedeagus).
Achilia caneloi Franz, 1996: 122 (**syn. nov.**).

Type material (5 ex.): CENTRAL CHILE: Región Valparaíso: Quillota Prov.: MHNS; 1 ♂ (Holotype of *A. temporalis*) labels verbatim "Holotype / Quillota; P. Germain / *Achillia temporalis* / *temporalis* (handwritten by Jeannel) / CHILE, M.N.H.N., Typo, n. 1853". – MNHN, 1 ♂ (Paratype of *A. temporalis*); labels verbatim "Paratype / Quillota, Germain; IV.1898 / *temporalis* (handwritten by Jeannel)". – MNHN, 1 ♂ and 1 ♀ (Paratypes of *A. temporalis*); labels verbatim "Paratype / Quillota, Germain". – Región Coquimbo: Choapa Prov.: NHMW; 1 ♀ (Holotype of *A. caneloi*); labels verbatim "Holotype / Bosque de Canelo; nordl. Los Vilos; Chile; H. Franz /*Achillia caneloi* m. (handwritten by Franz)".

Additional material examined (91 ex.): CENTRAL CHILE: Región Valparaíso: Quillota Prov.: MHNS; 2 ♀ (mislabeled as paratype of *Achilia temporalis* n. 2078 but there are two specimens on the same pin); Quillota; P. Germain. – Petorca Prov.: MHNS; 1 ♂ and 1 ♀ (mislabeled as paratype of *Achilia temporalis* n. 1854 but there are two specimens on the same pin); Zapallar; 20.III.1954; G. Kuschel. – Valparaíso Prov.: MHNG; 1 ♂; Bosque de Quintero; 1963; H. Franz. – NHMW; 1 ♂ (identified as *A. bifrons*); same data. – MHNS; 1 ♀; same locality; II.1968; J. Solervicens. – San Antonio Prov.: MNHS; 1 ♂ (identified as *A. elfridae*); Algarrobo; 21.VII.1951; G. Kuschel & L. E. Peña. – MNHN; 1 ♂ (identified as *A. elfridae*); Algarrobo; 21.VII.1951; G. Kuschel & L. E. Peña. – Región Coquimbo: Prov. Choapa: MHNG; 2 ♂; Hda Illapel; 600 m; 16.XI.1954; L. E. Peña. – FMNH (FMHD #54-66); 2 ♂; El Bato, Illapel, Coquimbo; 600 m; X.1954; L. E. Peña. – FMNH; 2 ♂ and 2 ♀; El Bato, Illapel Coquimbo; V-VI.1960; L. E. Peña. – NHMW; 1 ♂ (identified as *A. bifrons*); Quebrada La Palma, Hacienda La Palma, S of

Ovalle; 1963; H. Franz. – NHMW; 33 ♂ and 38 ♀ (identified as *A. bifrons*); Bosque de Canelo, N- Los Vilos; H. Franz. – MHNG; 1 ♂; Los Vilos, nr. P-B. 269; 05.XII.1965; Hungarian soil-Zool. Exp.; A. Zicsi. – FMNH; 1 ♂; Ñague, Los Vilos; V-VI.1960; L. E. Peña.

Description: Body 1.55-1.85 mm long, generally entirely reddish with slightly darkened abdomen, some specimens darker; palpi yellowish.
Male: Head as in Figs 58, 60 & 62, very wide, with slightly raised occipital region and frons, the latter flattened laterally with enlarged and sharp lateral margins, and crossed by transverse wide U-shaped sulcus originating posterior to antennal tubercles; frontal lobe very large and slightly convex, punctate and with slight medial carina separated from frons by prominent ridge angled posteriorly at middle. Antennae (Fig. 19) with scape and pedicel longer than wide; antennomeres III-VII about as long as wide; antennomere VIII wider than long; antennomere IX slightly wider than VIII and slightly wider than long; antennomere X distinctly wider than long and wider than IX; antennomere XI moderately elongate, about as long as VII-X combined. Metaventrite with deep and wide transverse sulcus on apical two-thirds, sulcus with prominent margins. First abdominal sternite slightly raised and flattened at middle; remaining abdominal sternites flattened at middle. Mesotibiae with distal half swollen and densely pubescent. Aedeagus (Fig. 6) 0.265-0.275 mm long, with ovoidal dorsal plate narrowed apically; dorsal longitudinal struts slightly divergent. Parameres relatively wide with very large and long recurved seta on well-developed outer lobe; apical portion of parameres slightly enlarged, prolonged laterally as short spine; apex bearing two long ventral medial setae. Copulatory pieces consisting of pair of subequal and short lateral sclerites that are slightly enlarged at apex, recurved, and more robust basally.
Female: Similar to male except head not modified; antennae shorter; eyes smaller; metaventrite, abdominal sternites, and legs unmodified.

Collecting data: The label data indicate a very long collecting period from November to July.

Distribution: *Achilia temporalis* occurs in Central Chile (Región Valparaíso and Región Coquimbo) from San Antonio to Choapa Provinces (Fig. 64: green squares).

Comments: We have examined the holotype of *A. caneloi* Franz, 1996. Despite its missing abdomen (lost by Franz) we identifed it as a female (and not a male as stated by Franz) of *A. temporalis*, and consequently place *A. caneloi* Franz, 1996 as a junior synonym of *A. temporalis* Jeannel, 1962 (**syn. nov.**).
The males of *A. temporalis* are easily distinguished from other species of the *A. cosmoptera* group by the shape of the head (Figs 58, 60, 62), antennae (Fig. 19) and aedeagus (Fig. 6). For characters to distinguish the females of *A. temporalis* from those of *A. bifrons* see the "Comments" section of the latter species.

Species removed from the *Achilia cosmoptera* species group

Achilia andina Franz, 1996

Achilia andina Franz, 1996: 119, fig. 70 (aedeagus).

Comments: We have examined the holotype and paratypes of this species, which are housed in the NHMW. In our opinion *Achilia andina* is very similar to members of the genus *Pseudachillia* Jeannel, 1964. However we decided to investigate in more detail the identity and generic assignment of this taxon in a forecoming study dealing with the members of *Pseudachillia*.

Achilia maipoensis Franz, 1996

Achilia maipoensis Franz, 1996: 119, fig. 71 (aedeagus).

Comments: We have examined the holotype and paratypes of this species, which are housed in the NHMW. In our opinion *Achilia maipoensis* is very similar to members of the genus *Pseudachillia* Jeannel, 1964. However we decided to investigate in more detail the identity and generic assignment of this taxon in a forecoming study dealing with the members of *Pseudachillia*.

Achilia pseudangularis Franz, 1996

Achilia pseudangularis Franz, 1996: 118 fig. 68 (aedeagus).

Comments: We have examined the holotype of *A. pseudangularis* housed in the NHMW. It is a female of an *Achilia* sp. that is not dissected but is mounted on the same pin as a polyvinyl acetate slide bearing a microcospic preparation of an aedeagus that is very similar to that of species of the genus *Achillidia* Jeannel, 1962. According to Franz (1996: 188, fig. 68) the holotype of *A. pseudangularis* is a male, and the aedeagus he figured corresponds to that in the microscopic preparation. So we selected the mounted aedeagus as being the holotype and, based on its observation, remove the species from the *cosmoptera* species group. However we decided to investigate in more detail the identity and generic assignment of this taxon in a forthcoming study dealing with the members of *Achillidia*.

Achilia quinteroi Franz, 1996

Achilia quinteroi Franz, 1996: 118, fig. 69 (aedeagus).

Comments: We have examined the holotype and the paratype of this species, which are housed in the NHMW. In our opinion *A. quinteroi* is very similar to the members of the genus *Achillidia* Jeannel, 1962. However we decided to investigate in more detail the identity and generic assignment of this taxon in a forthcoming study dealing with the members of *Achillidia*.

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REFERENCES

Blanchard C.E. 1851. Fauna Chilena, Insectos, Coleópteros. LVI. Pselafianos (pp. 561-564). *In:* Gay C., Historia física y política de Chile, Zoología. *Imprimerie Maulde & Renou, Paris.* Vol. 5: 1-564+ii, pls 1-32.

Camousseight A. 1980. Catálogo de los Tipos de Insecta depositados en la colección del Museo Nacional de Historia Natural (Santiago, Chile). *Publicaciones ocasionales del Museo Nacional de Historia Natural* 32: 1-45.

Chandler D.S. 2001. Biology, Morphology, and Systematics of the Ant-like Litter Beetle Genera of Australia (Coleoptera: Staphylinidae: Pselaphinae). *Memoirs on Entomology, International* 15: i-viii, 1-560.

Franz H. 1996. Neue Beiträge zur Kenntnis der Pselaphidenfauna von Chile und Argentinien (Coleoptera: Pselaphidae). *Koleopterologische Rundschau* 66: 83-146.

Jeannel R. 1962. Les Psélaphides de la Paléantarctide Occidentale (pp. 295-479). *In*: Deboutteville C.D. & Rapoport E. (eds), Biologie de l'Amérique Australe. Vol. I. Etude sur la Faune du Sol. *Centre National de la Recherche Scientifique, Paris.*

Jeannel R. 1963. Les Psélaphides de la Paléantarctide Occidentale. Supplément (pp. 351-369). *In*: Deboutteville C.D. & Rapoport E. (eds), Biologie de l'Amérique Australe. Vol. 2. Etude sur la Faune du Sol. *Centre National de la Recherche Scientifique, Paris.*

Jeannel R. 1964. Sur quelques Psélaphides du Chili. *Revue Française d'Entomologie* 31(1): 5-12.

Kurbatov S. A., Sabella G. 2015. A revision of the Chilean Brachyglutini – Part 1. Some taxonomic changes in Brachyglutini and preliminary diagnosis of *Achilia* Reitter, 1890 (Coleoptera: Staphylinidae: Pselaphinae). *Revue suisse de Zoologie* 122(2): 297-306.

Kurbatov S. A., Cuccodoro G., Sabella G. 2018. A revision of the Chilean Brachyglutini – Part 3. Revision of *Achilia* Reitter, 1890: *A. frontalis* species group (Coleoptera: Staphylinidae: Pselaphinae). *Revue suisse de Zoologie* 125(1): 165-188.

Kurbatov S. A., Cuccodoro G., Sabella G. 2019. A revision of the Chilean Brachyglutini – Part 5. Revision of *Achilia* Reitter, 1890: *A. cornuta, A. spinifer, A. cribratifrons,* and *A. monstrata* species groups, with description of seven new species (Coleoptera: Staphylinidae: Pselaphinae). *Revue suisse de Zoologie* 126(2): 355-371.

Raffray A. 1895. Revision du genre *Tyropsis* Saulcy (*Aplodea* Reitter) et description de deux genres nouveaux du même groupe. *Annales de la Société Entomologique de France* 64: 391-400.

Raffray A. 1904. Genera et Catalogue des Psélaphides. *Annales de la Société Entomologique de France* 73: 1-400.

Reitter E. 1883. Beitrag zur Kenntniss der Pselaphiden-Fauna von Valdivia. *Deutsche Entomologische Zeitschrift* 27: 47-54, pl. I.

Reitter E. 1885. Beitrag zur Kenntniss der Pselaphiden-Fauna von Valdivia, Zweiter Theil. *Deutsche Entomologische Zeitschrift* 29: 321-332, pl. II.

Sabella G., Kurbatov S. A., Cuccodoro G. 2017. A revision of the Chilean Brachyglutini – Part 2. Revision of *Achilia* Reitter, 1890: *A. crassicornis, A. tumidifrons, A. bifossifrons* and *A. lobifera* species group (Coleoptera: Staphylinidae: Pselaphinae). *Revue suisse de Zoologie* 124(1): 119-140.

Sabella G., Cuccodoro G., Kurbatov S. A. 2019. A revision of the Chilean Brachyglutini – Part 4. Revision of *Achilia* Reitter, 1890: *A. puncticeps* and *A. approximans* species groups, with description of seven new species (Coleoptera: Staphylinidae: Pselaphinae). *Revue suisse de Zoologie* 126(1): 127-145.

Sabella G., Cuccodoro G., Kurbatov S. A. 2020. A revision of the Chilean Brachyglutini – Part 6. Revision of *Achilia* Reitter, 1890: *A. grandiceps, A. valdiviensis,* and *A. bicornis* species groups (Coleoptera: Staphylinidae: Pselaphinae). *Revue suisse de Zoologie* 127(1): 129-156.

Schaufuss L. W. 1886. Beschreibung neuer Pselaphiden aus der Sammlung des Museums Ludwig Salvador. Ein Beitrag zur Fauna Brasiliens, der Kgl. niederländischen Besitzungen in Indien und Neuholland. *Tijdschrift voor Entomologie* 29: 241-296.

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Taxonomic notes on the genus *Cyphochilus* (Coleoptera: Scarabaeoidea: Melolonthinae) (part 4) with description of eight new species from Indochina and China

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Abstract: *Cyphochilus brancuccii* n. sp., *C. hlai* n. sp., *C. nanzhao* n. sp., *C. keithi* n. sp., *C nguyendui* n. sp., *C. nguyenvanvinhi* n. sp., *C. phamthinhiae* n. sp., and *C. zianii* n. sp. are described based on the study of about 570 specimens. These species are largely distributed in Laos and Vietnam, marginally in Myanmar, Thailand, and South China. Previously they were confused with *C. ventriglaber* Brenske, 1903. The parameres and distribution of the nine species here treated are illustrated.

Keywords: Systematics - taxonomy - distribution - China - Thailand - Laos - Vietnam - Myanmar - Scarabaeidae.

INTRODUCTION

The members of the genus *Cyphochilus* Waterhouse, 1867 are quite exceptional among Melolonthini having relatively uniform external morphology in contrast to a much diversified morphology of the paramera. The diversified paramere morphology offers an extraordinary tool to easily identify male of the species and formulate hypotheses on interspecific relationships based on morphological affinities. The use of paramera for the identification of a *Cyphochilus* species was first adopted by Frey (1971), followed by Nomura (1977). During 2020, 22 new species were described and the paramera of their sibling species illustrated (Sabatinelli, 2020a, b, c). This study presents the results of the study of about 582 specimens from Indochina and China, previously often confused in the collections with *C. ventriglaber* Brenske, 1903.

MATERIAL AND METHODS

Specimens: The following acronyms set by Evenhuis (2007) identify the collections housing the examined material:

HNHM Hungarian Natural History Museum, Budapest, Hungary;
IEBR Institute of Ecology and Biological Resources, Hanoi, Vietnam;
IECA Institute of Entomology, Biology Centre of the Czech Academy of Sciences, České Budějovice, Czech Republic (ex coll. Aleš Bezděk);
ISNB Institut Royal des sciences naturelles, Brussel, Belgium;
MHNG Muséum d'histoire naturelle, Genève, Switzerland;
MNHN Muséum national d'Histoire naturelle, Paris, France;
MZUF Museo Zoologico "La Specola", Firenze, Italy;
NHMB Naturhistorisches Museum, Basel, Switzerland;
NHMW Naturhistorisches Museum, Wien, Austria;
NMPC National Museum, Prague, Czech Republic;
PCAR Andreas Reichenbach private collection, Leipzig, Germany;
PCDK Denis Keith private collection, Chartres, France;
PCMN Milan Nikodým private collection, Prague, Czech Republic;
ZMHB Museum für Naturkunde, Berlin, Germany.
ZMUH Zoologisches Institut und Zoologisches Museum, Universität von Hamburg, Germany.

All specimens in the collection of the first author (GS) were donated to the MHNG and integrated into the general collection. Type specimens held by the MHNG and registered in their collection database have a catalogue number with the format MHNG-ENTO-######. Holotype specimen label information is reported *verbatim* and the used signs indicate:

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// separates data on different labels; if not indicated otherwise, they are on rectangular white labels;
/ line separation on same label;
[...] contain comments of the authors relating to *verbatim* data;
[sic] indicates a mistake in the original data label;
(H) indicates handwritten;
(P) indicates printed.

All other specimen information follows the standards of the journal, with specimen lots separated by the character combination ". – ".

Male genitalia: Aedeagi were dissected and cleaned manually without any chemical treatment, then glued to a cardboard pinned under each specimen from which they were removed.

Descriptions: Due to the relative uniformity of the external morphology of *Cyphochilus*, in contrast with the high diversification of the parameres, only the characters useful for identification and for differential diagnosis are indicated in the descriptions. We refer to the detailed description of *C. ventriglaber* Brenske, 1903 for integrating the description.

Morphological terminology: Follows Torre-Bueno *et al.* (1989).

Images and Mapping: A Leica DFC425 camera in conjunction with a Leica M205-C stereo microscope was used to produce source images, which were subsequently processed using the software Zerene Stacker, and adjusted and grouped in plates using Adobe Photoshop. Distribution maps were generated using QGIS 2.8.2 based on the geographical coordinates.

Measurements and abbreviations: Characters, measurements, mensural procedures, and ratios are as follows:

BL: Body length, measured from anterior margin of clypeus to apex of elytra, in dorsal view;
BW: Body width, measured across the elytral humeri, in dorsal view;
BWX: Greatest body width, measured across the elytral maximal width, in dorsal view;
CW/L: Clypeal ratio, derived from width measured along clypeo-frontal suture divided by medial length of clypeus;
F/O: Interocular ratio, derived from minimum frons width across eyes divided by transverse compound eye diameter in dorsal view;
A2-7L/CL: Antennal ratio, derived from length of basal antennomers 2-7 divided by antennal club length;
PnW/L: Pronotal ratio, derived from pronotal greatest width divided pronotal length along midline, in dorsal view.

TAXONOMY

Genus *Cyphochilus* Waterhouse, 1867

Type species: *Melolontha candida* Olivier, 1789 by subsequent designation (Medvedev, 1951: 231).

Synthetic history of the genus: Waterhouse, 1867: description of the genus and of 5 species; Sharp, 1876: description of 3 species; Nonfried, 1893: description of one species; Fairmaire, 1902: description of 2 species; Brenske, 1903: description of 8 species; Dalla Torre, 1912: catalogue of 26 species; Moser, 1915: description of one species and syn. *ventritectus* Brenske, 1903 = *ochraceosquamosus*; Arrow, 1938: description of one species; Medvedev, 1951: designation of the type species *C. candidus* (Olivier, 1789); Frey, 1971: description of one species; Sabatinelli & Pontuale, 1998: description of *Dedalopterus* with a redefinition of its closest genera *Malaisius* Arrow, 1941 and *Cyphochilus*; Li & Yang, 1999: revision of *Malaisius* and notes on *Cyphochilus*; Krajčik, 2012: catalogue of 32 species; Bezdek, 2016: catalogue of 12 Palaearctic species; Sabatinelli, 2020a: designation of several lectotypes, several synonymies proposed and 10 species described; Sabatinelli, 2020b: description of 9 new species and one subspecies, a checklist of valid 46 species; Sabatinelli, 2020c: designation of *C. tonkinensis* lectotype and description of 3 species.

Diagnosis: The following combination of characters distinguishes *Cyphochilus* from the other related genera of Melolonthinae in order of discriminating importance: labrum strongly asymmetric, decamerous antennae, antennal club of 3 antennomeres longer in the males than in females, upper part of the body covered only by scales, apical palpomere of maxillary palps narrow, elongate without any callus or excavation on its outer surface, claws long and with basal tooth; parameres generally strongly asymmetric. The asymmetry of the labrum alone, defines the members of the genus *Cyphochilus* among all Scarabaeoidea.

Remarks: Considering the species described in the present work, 56 species belong to the genus *Cyphochilus*. The genus is distributed in the Oriental part of the Palaearctic Region, as defined by Löbl & Smetana (2006) and marginally, in the very northern part of the Oriental Region. A synthetic history of the genus, full bibliographic references and an updated catalogue of species are provided by Sabatinelli (2020b) while the morphological affinities with other genera are discussed in Sabatinelli (2020a, b).

In the present work, we are treating a complex of species morphologically close to *Cyphochilus ventriglaber* having in common the following characters: body ovoid, larger in females; antennal club of males longer than antennomeres 2-7; eyes relatively small and not very produced externally; elytra

with visible interstriae although not very elevated; mesosternum not produced into apophysis; pygidium of males with ventral margin narrow; last ventrite of females as the proceeding one, smooth, shining, without punctures on medial part; aedeagus with median lobe not developed and parameres strongly asymmetric.
Considering the morphology of ventrites and aedeagus, the ventriglaber-complex of species can be further divided into three cluster of species and as such, the species are treated in this work.

Cluster A

Species with median part of ventrites smooth without scales or punctures; parameres slender, the distal part slightly bent dorsally or externally (Figs 1-6). This group includes: *Cyphochilus ventriglaber* and *C. nanzhao* n. sp.

Cyphochilus ventriglaber Brenske, 1903
Figs 1-3, 7

Cyphochilus ventriglaber Brenske, 1903: 381.

Type material examined: Holotype, ZMHB, ♂; *VIETNAM //* Tonkin / Montes Manson [sic, Mẫu Sơn, Lạng Sơn Province] / April, May 2-3000' / H. Fruhstorfer (P) // Type / 1089 / Brsk (H) // *Cyphochilus* / *ventriglaber* / Brsk (H) // Coll. Brenske (P) // (Fig. 3a).

Additional material examined: 19 specimens. *VIETNAM: Lạng Sơn Province:* ZMHB: 1 ♀; MHNG: 3 ♂, 1 ♀; same data as holotype. – *Vĩnh Phúc Province:* NHMB: 3 ♂; Tam Đảo; 20-28.VI.1990; Jan Strnad leg. – NHMB: 1 ♂; Tam Đảo; 5-10.VI.1989; Brantlová leg. – IEBR: 1 ♂; Tam Đảo National Park; 3.VII.2003; Hoang Vu Tru leg. – *Cao Bằng Province:* IEBR: 3 ♂; Nguyên Bình, Phia Oắc - Phia Đén National Park; 13.V.2010; 1500-1600 m; Hoang Vu Tru leg. – IEBR: 2 ♂; same locality as previous; 11.VIII.2012; Hoang Vu Tru leg. – *Hà Giang Province:* PCDK: 2 ♂, 2 ♀; Hà Giang Prov.; VI-VII.2012; Do Manh Cuong leg.

Redescription of holotype male
Body: Ovoid; BL: 22.5 mm, BW: 8.6 mm, BWX: 11.4 mm situated at midpoint of elytra; integument black excluding legs and appendices that are light brown; upper surface covered with ochraceous scales not forming spots or stripes but more densely aggregated along external margins of elytra where they are white; pygidium and abdomen without metallic reflex.
Head: Clypeus transverse with anterior margin largely rounded (CW/L: 3.2), laterally not continuous with canthus, flat, separated from frons by suture, with anterior margin slightly reflected; frons depressed medially, large, thus making eyes relatively small (F/O: 4.5), lateral margin near eyes not elevated; vertex depressed; antenna decamerous; antennal club trimerous, elongate, more than twice longer than preceding antennomeres 2-7 (A2-7/CL: 0.4); footstalk with third and fourth antennomeres subequal in length; claws not cleft at apex, large at base and with basal tooth beneath, lower margin entire, dorsal margin uniformly curved; apical maxillary palpomere narrow (five times longer than wide), not excavated; labrum deeply sinuate, strongly asymmetric; mentum transverse, with Y-shaped carina.
Pronotum: Transverse (PnW/L: 2), with lateral margin angulated in the middle, not serrated, without setae, anterior and posterior margins not margined; anterior angles acute and prominent, basal angles obtuse and rounded; mesoventrum not produced between mesocoxae; metaventrum with long hairs; metepisternum narrow, more than three times longer than wide with metepimera small.
Elytra: With well-developed humeral callus and four elevated costae in addition to the sutural one, not reaching the apex of elytra where the surface is strongly angulate toward the pygidium.
Wings: Completely developed.
Abdomen: Ventrites with uniform scales, not aggregated at the lateral margins, connate, with sutures absent in middle; ventrite VI not retracting under ventrite V; distal margin of the ventrite VIII not sinuate; last two ventrites medially smooth, without scales or punctures; last spiracle located on suture between visible ventrite V and propygidium.
Pygidium: Triangular, convex, with distal margin not reflected and ventral surface narrowly developed, thus not mucronate.
Legs: Anterior coxae transverse, not prominent and contiguous to each other; mesofemur not enlarged; protibiae 3-toothed with the basal one more distant than the two distal; with internal spur, located between the basal and median external tooth; external margin of protibiae not transparent; meta- and mesotibiae without complete transverse carina only externally with a tubercle; dorsal margin of metatibiae without teeth or spines; tarsomeres thick and short, sparsely setaceous beneath and with sparse minute scales above; basimetatarsomere shorter than second; metacoxae not close to the mesocoxae.
Aedeagus: Endophallus membranous; median lobe not developed; parameres asymmetric, parameres slender (Fig. 2), right paramere with ventral and dorsal margin subparallel and apex enlarged and bent externally (Figs 1-2), left paramere with apex enlarged and bent dorsally, on dorsal margin at the base with a very small thorn (Figs 2-3).

Variability in males: BL: 23.3-25.4 mm ($x = 24.5$; $n = 11$). Some well-preserved specimens have vestiture of the upper part of the body with more dense scales more often whitish; over eleven males specimens examined, nine have a scale vestiture white instead of ochraceous as the holotype.

Females and variability: Body more ovate than in males; BL: 22.3-22 mm (n = 4); BW: 9.2; BWX: 11.7; antennal club ovate, shorter than preceding antennomeres (A2-7/CL: 1.4); protibiae strongly 3-toothed with teeth almost equidistant with each other; wings and humeral callus as developed as in males; metacoxae not close to the mesotibiae as in males; ventrite VIII not excavated medially, smooth without scales or punctures; pygidium relatively convex with a larger base than in males, marginal apex not reflected, ventral surface very narrow almost absent.

Type locality: *Cyphochilus ventriglaber* was described from a series of specimens collected by members of the French Tonkin Expeditionary Corps during the colonization of Indochina, in the Mount Mẫu Sơn (21°45'12" N 106°57'00" E), where the French built a military base and a cluster of residential houses. Mount Mẫu Sơn name refers to a mountain in Lộc Bình District, Lạng Sơn Province, in northeast Vietnam. It is located about 170 km northeast of Hanoi and about 30 km east of Lạng Sơn City close to the border between Vietnam and China. The highest peak of Mount Mẫu Sơn reaches about 1600 m above sea level.

Distribution: This species is endemic to Vietnam and known from few specimens collected in the northeastern part across Lạng Sơn, Vĩnh Phúc, Cao Bằng and Hà Giang Provinces (Fig. 7).

Remarks: The male specimen preserved at the ZMHB has the exact labelling indicated in the description by Brenske for which he also indicated "Type 1089", thus the specimen has to be considered as holotype by original description. Several specimens of medium size *Cyphochilus* with elytra with elevated striae, from Northern parts of Thailand, Laos and Vietnam, have been attributed to *C. ventriglaber*. In reality, the aedeagal morphology distinguishes nine species, eight of which are described as new thereafter. Among them, *C. ventriglaber* is close to *C. nanzhao* n. sp. from which is easily recognizable by the shape of parameres. In *C. ventriglaber* the apex of right paramere has dorsal and ventral margins subparallel, enlarged and slightly bent externally at the apex; left paramere is enlarged and slightly bent dorsally at apex without any dorsal apophysis. In *C. nanzhao* the right paramere is narrowed then enlarged at apex and strongly bent dorsally; left paramere terminates in a point bent externally and a large thorn is present on the dorsal margin toward base

Figs 1-6. Paramera in right (apex to the right), dorsal (apex to the right) and left (apex to the left) view: (1-3) *Cyphochilus ventriglaber* Brenske, 1903, holotype; (4-6) *C. nanzhao* n. sp., holotype. Scale bars = 0.5 mm. (3a) Original labels of *C. ventriglaber* Typus.

(Figs 1-3 versus 4-6). The geographical distribution area of the two species is very distant separated by the Mekong Basin.

Cyphochilus nanzhao Sabatinelli n. sp.

Figs 4-6, 7

Holotype: MHNG (MHNG-ENTO-85538); ♂; THAILAND // Thailand, Chiang Mai Prov. / Ang Khang region, 1600±100 m / 19°53'45"N 99°02'45"E / L. Dembický leg. 2-7.V.2009 (P) // Holotypus ♂ / *Cyphochilus* / *nanzhao* / G. Sabatinelli, 2021 (T on red) //.

Paratypes: 2 specimens. *CHINA*: *Yunnan Province:* NMPC: 1 ♂; Zizhi [Tengchong, Baoshan City], at light in the village; 25°43.7'N 98°34.1'E, 1995 m; 29.VI.8.VII.2016; J. Hájek & J. Růžička leg. – MHNG (MHNG-ENTO-85539): 1 ♀; W. Yunnan, 60 km Tengchong [Baoshan City], 2200 m, 20.V.2006; S. Murzin leg.

Description of the holotype male

Body: Subcylindrical, BL: 19.4 mm, BW: 7.6 mm, BWX: 9.7 mm situated at midpoint of elytra; integument black except for legs and appendices light brown; dorsal surface with dark-ochraceus scales more densely aggregated at the lateral margins and apex of elytra.

Head: CW/L: 3.4; anterior edges of clypeus largely rounded; frons deeply depressed, large, thus eyes relatively small (F/O: 5.5); antennal club twice longer than antennomeres 2-7 (A2-7/CL: 0.5).

Pronotum: Transverse (PnW/L: 2.2), strongly convex; anterior angles right and basal angles obtuse.

Elytra: With four elevated costae, in addition to sutural one, not reaching the elytral apex. Thoracic ventra with short, white setation and scales; mesoventrum not developed or visible between the mesocoxae. Abdomen: ventrites medially smooth without scales or punctures; ventrite VIII medially depressed; pygidium ventral surface narrow and depressed medially.

Legs: Protibiae tridentate with basal teeth small; equally distant with each other.

Aedeagus: Parameres with median lobe not developed (Fig. 5); right paramere narrowed in the pre-apical portion then enlarged distally, curved dorsally and with an acute dorsal margin (Figs 4-5); left paramere much shorter than right ending in an acute point bent externally, dorsal margin with large vertical thorn (Figs 5-6).

Male paratype: BL: 20.2 mm; in this specimen the colour of scale vestiture of the upper part of the body is white instead of ochraceous as with the holotype.

Female paratype: Body larger than in males; BL: 19.7-21.5 mm; BW: 8.5; BWX: 10.6; antennal club ovate, shorter than preceding antennomeres 2-7 (A2-7/CL: 1.19), scale vestiture of the upper part of the body snow-white with lateral margins yellowish; ventrites uniformly with scales and punctures.

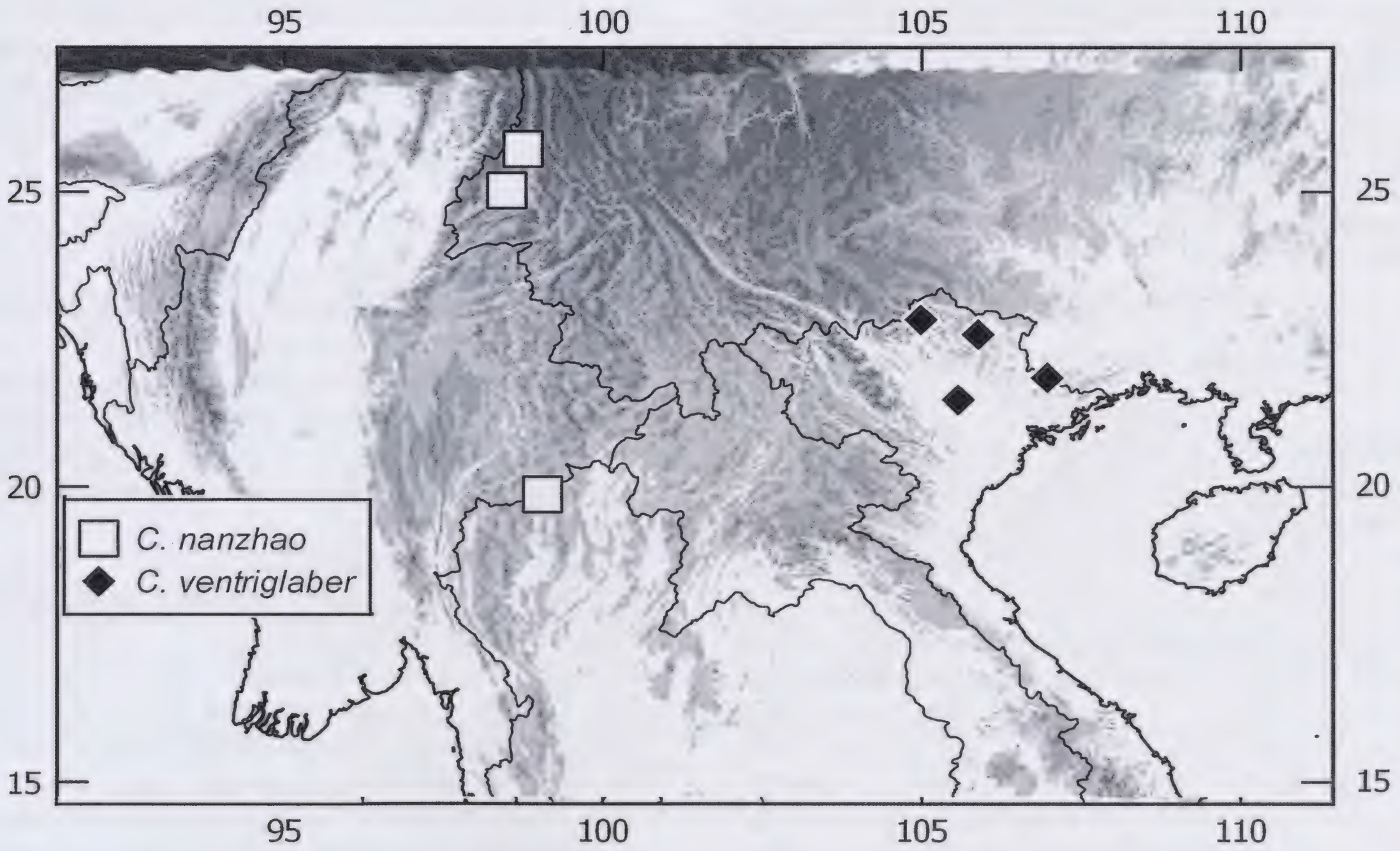


Fig. 7. Geographical distribution of *C. ventriglaber* and *C. nanzhao* n. sp.

Etymology: Nanzhao, literally Southern Zhao, was a dynastic kingdom that flourished in what is now southern China and Southeast Asia during the 8th and 9th centuries. It was centred on present-day Yunnan. Noun in apposition.

Type locality: Ang Khang is located in the Fang district of Chiang Mai Province in Thailand; it is part of the Daen Lao Range that straddles both sides of the Burmese-Thai border, the peak of Doi Ang Khang is 1928 m.

Distribution: Only three specimens are known: the holotype from north Thailand and 2 paratypes from West Yunnan bordering Myanmar (Fig. 7). I examined also a couple of specimens from Mount Emei, in Emeishan City, Sichuan; however, the male parameres are quite different from those of the holotype and paratype. Due to the distance of Mount Emei from Thailand and West Yunnan, I did not include those Sichuan specimens in the type series as it could be a different species for which the study of much more specimens and populations is necessary in order to decide their systematic value.

Remarks: *Cyphochilus nanzhao* n. sp. is morphologically related to *C. ventriglaber*, please see above for their differential diagnosis.

Cluster B

Species with median part of ventrites smooth without scales or punctures; parameres stocky, right paramere larger with distal part curved, left paramere with distal part curved externally (Figs 8-19). This group includes *Cyphochilus brancuccii* n. sp., *C. hlai* n. sp., *C. nguyenvanvinhi* n. sp. and *C. zianii* n. sp. These species are very similar in external morphology and pragmatically can be only distinguished by the paramere morphology which is very distinctive for each species as reported in Table 1.

Cyphochilus brancuccii Sabatinelli n. sp.

Figs 8-10, 31

Holotype: MHNG (MHNG-ENTO-85546); ♂; *LAOS* // Laos, Phôngsali Province / Muang Khoa [Khua] district / Ban Phianglan, [21.0778° N, 102.5097° E] May 2014 (P) // Holotypus ♂ / *Cyphochilus* / *brancuccii* n. sp. / G. Sabatinelli, 2021 (T on red) //.

Paratypes: 221 specimens. *LAOS, Phôngsali Province:* MHNG: 30 ♂; 7 ♀; same data as holotype – *Houaphanh Province*: ZMHB: 46 ♂♂, 20 ♀♀; Ban Saleuï, Phou Pan Mt. [Phu Phan Mt.]; 20°12'N 104°01'E, 1300-1900 m; 11.IV.-15.V.2012; C. Holzschuh leg. – NMPC: 1 ♂, 1 ♀; PCMN: 1 ♂; same locality as previous; 20°15'N 104°02'E, 1500-2000 m; 26.IV.2001; D. Hauck leg. – PCDK: 1 ♂, 1 ♀; Ban Saleuï; 15.IV.5.V.2012; Tingaud leg. – NMPC: 6 ♂; Ban Saleuï, 30 km S of Xam Neua; 20°13'39"N 103°59'33"E, 1500 m, 6-17.V.2004; P. Kresl leg. – NHMB: 8 ♂, 1 ♀; Phou Pane Mt. [Phu Phan Mt.]; ~23°[?]13'N 104°00'E, 1-16. VI.2009, 15350-1500 m, M. Brancucci leg. – NHMB: 8 ♂; same locality and date as previous; 20°13'09"N 103°59'54"N-104°00'03"N; 1480-1550 m; Z. Kraus leg. – NMPC: 31 ♂, 4 ♀; IECA: 5 ♂, 1♀; same locality as previous; 20°13'09"N 103°59'54"E-104°00'03"E, 1480-1510 m; 22.IV.-14.V.2008; V. Kubáň leg. – NMPC: 1 ♂, 1 ♀; IECA: 3 ♀; same locality as previous; 20°15'N 104°02'E; 1500-2000 m, 26.IV.-11.V.2001; J. Bezděk leg. – NHMB: 14 ♂; same locality as previous; 20°12'N 104°01'E, 1500-1900 m; 17.V.-3.VI.2007; M. Brancucci leg. – NMPC: 12 ♂, 2 ♀; same locality as previous; 17.V.-3.VI.2007, ~1750 m; V. Kubáň leg. – NMPC: 6 ♂; NHMB: 7 ♂; Phu Phan Mt.; ~1750 m, 20°12.328'N 104°00.621E, 17.V.-3.VI.2007; V. Kubáň leg. – NHMB: 1 ♂; Ban Saleuï to Phou Pane Mt. [Phu Phan Mt.]; 20°12-13.5'N 103°59.5'-104°01'E, 1340-1870 m; 10.V.-16.VI.2009; M. Brancucci & local collector leg. – NHMB: 1 ♂; same locality as previous; 1300-1900 m; 9-17.VI.2009; M. Geiser leg. – NHMB: 1 ♂; same locality as previous; 1300-1900 m; IV.2012; K. Sisoutham & local collector leg.

Description of the holotype male

Body: Ovoid, BL: 19.4 mm, BW: 7.6 mm, BWX: 9.7 mm situated at midpoint of elytra; dorsal integuments black, ventral integuments, legs and appendices reddish-brown; dorsal surface with dirty-white scales more densely aggregated at the lateral margins and apex of elytra where they are yellowish.
Head: CW/L: 3.4; anterior angles of clypeus largely rounded, anterior margin straight; frons depressed, large, thus eyes relatively small (F/O: 5.5); antennal club twice longer than antennomeres 2-7 (A2-7/CL: 0.5).
Pronotum: Transverse (PnW/L: 2.2), strongly convex; anterior angles right and basal angle obtuse.
Elytra: With four elevated costae, in addition to sutural one, not reaching the elytral apex.
Thoracic sterna: With short, white setation and scales; mesoventrum not developed nor visible between the mesocoxae.
Abdomen: Ventrites medially smooth without scales or punctures.
Pygidium: Ventral surface narrow.
Legs: Protibiae tridentate with basal teeth small; the two apical teeth close to each other.
Aedeagus: Parameres with median lobe not developed (Fig. 9); right paramere narrowed in the pre-apical portion then strongly enlarged distally, curved dorsally and with an acute dorsal margin (Figs 8-9); left paramere much shorter than right, ending in an acute point bent externally, dorsal margin with a preapical large thorn directed externally (Figs 9-10).

Male paratypes: BL: 19.2-23.3 mm (x = 20.2; n = 50); one-fourth of male specimens have brown scale vestiture instead of dirty-white as in holotype.

Female paratypes: Body larger than in males; BL: 21.3-25.2 mm (x = 23.5; n = 25); BW: 8.5; BWX: 10.6; antennal club ovate, shorter than preceding antennomeres 2-7 (A2-7/CL: 1.2); in some specimens, legs are lighter coloured than ventral integuments; all females specimens have vestiture scales dirty-white, never brown as in some males.

Etymology: The species is dedicated to the late Michel Brancucci who starting in 2003, contributed fundamentally to many of new findings among beetle diversity of Laos; this act is to keep alive the memory of a highly respected colleague and my personal mentor.

Type locality: Muang Khua is a village in Laos, near the Vietnamese border, in the province of Phôngsali.

Distribution: *Cyphochilus brancuccii* n. sp. along with *C. nguyendui* n. sp. is one of the most abundant *Cyphochilus* species in the collections. *C. brancuccii* is distributed in North Laos in the Phôngsali and mainly Houaphanh provinces (Fig. 31).
The first author (GS) would like to point out that during some years Mr Li Jingke, a Chinese trader, sold beetles, including *Cyphochilus*, from improbable collecting locations. For this reason although we examined specimens of *C. brancuccii* sold by this trader putatively from Yunnan, Myanmar, Vietnam and Cambodia, they were not included in the type series. The presence of *C. brancuccii* outside of Laos should be confirmed.

Remarks: For the differential diagnosis with other close species of this informal subgroup see Table 1 and Figs 8-19.

Cyphochilus hlai Sabatinelli n. sp.

Figs 11-13, 31

Holotype: NMPC; ♂; *CHINA, Hainan:* // China, Hainan isl. 4-6.V.2011 / Limushan [Limu Shan] Mt. / forest administration centre (at light) / 19°10'30"N 109°44'33"E, 630 m / M. Fikáček, V. Kubeček & L. Li leg. (P) // Holotypus ♂ / *Cyphochilus* / *hlai* n. sp. / G. Sabatinelli, 2021 (T on red) //.

Paratypes: 2 specimens. MHNG (MHNG-ENTO-85540): 1 ♂; NMPC: 1♀; same data as holotype.

Description of the holotype male
Body: Ovoid, BL: 23.9 mm, BW: 8.9 mm, BWX: 11.5 mm situated at midpoint of elytra; dorsal and ventral integuments black, legs and appendices reddish-brown; dorsal surface with dirty-white scales more densely aggregated at the lateral margins and apex of elytra where they are yellowish.
Head: CW/L: 3.4; anterior angles of clypeus largely rounded, anterior margin straight; frons depressed, large, thus eyes relatively big (F/O: 3.4); antennal club twice longer than antennomeres 2-7 (A2-7/CL: 0.5).
Pronotum: Transverse (PnW/L: 2), strongly convex; anterior and basal angles right.
Elytra: With four elevated costae, in addition to sutural one, not reaching the elytral apex.
Thoracic sterna: With short, white setation and scales; mesoventrum not developed or visible between the mesocoxae.
Abdomen: Ventrites medially smooth without scales or punctures, last ventrite depressed medially.
Pygidium: Ventral surface narrow.
Legs: Protibiae tridentate with basal teeth small; the two apical teeth close to each other.
Aedeagus: Parameres with median lobe not developed (Fig. 12); right paramere large with apex curved

Table 1: Differential diagnosis for paramera of *Cyphochilus brancuccii* n. sp., *C. hlai* n. sp., *C. nguyenvanvinhi* n. sp. and *C. zianii* n. sp.

Species	Right paramere	Left paramere
Cyphochilus brancuccii	narrowed in the pre-apical portion then strongly enlarged distally, curved dorsally and with an acute dorsal margin (Figs 8-9);	shorter than right one, ending in an acute point bent externally, dorsal margin with a preapical large thorn directed externally (Figs 9-10).
Cyphochilus hlai	large with apex curved dorsally (Figs 11-12);	shorter than right one, ending in an acute point bent externally, dorsal margin with a large thorn directed externally (Figs 12-13).
Cyphochilus nguyenvanvinhi	distally enlarged and curved dorsally with bifid apex (Figs 14-15);	shorter than right one ending in an acute point curved externally (Figs 15-16).
Cyphochilus zianii	distally enlarged, curved dorsally and truncate at apex (Figs 17-18);	shorter than right one ending in an acute point curved externally (Figs 18-19).

Figs 8-19. Paramera in right (apex to the right), dorsal (apex to the right) and left (apex to the left) view: (8-10) *Cyphochilus brancuccii* n. sp., holotype; (11-13) *C. hlai* n. sp., holotype; (14-16) *C. nguyenvanvinhi* n. sp., holotype; (17-19) *C. zianii* n. sp., holotype. Scale bars = 0.5 mm.

dorsally (Figs 11-12); left paramere much shorter than right ending in an acute point bent externally, dorsal margin with a large thorn directed externally (Figs 12-13).

Male paratype: BL: 23.5 mm; no major differences from holotype.

Female paratype: Body larger than in males; BL: 22.2 mm; BW: 9.7; BWX: 12.9; antennal club ovate, shorter than preceding antennomeres 2-7 (A2-7/CL: 1.1).

Etymology: The Hlai, also known as Li or Lizu, are one of the 56 ethnic groups officially recognized by the People's Republic of China; the vast majority of Hlai live off the southern coast of China on Hainan Island where they are the largest minority ethnic group.

Type locality: Limu Shan National Forest Park in Hainan Island, covers a large area of basically primitive forests; the highest mountain in the forest park is Da Limu Ling (1412 m), and there are 19 mountains higher than 1000 m, 33 mountains higher than 800 m, 32 mountains of 500-800 m height, where the *Cyphochilus* specimens where collected and 9 mountains under 500 m.

Distribution: *Cyphochilus hlai* n. sp. appears endemic to Hainan Island (Fig. 31).

Remarks: For the differential diagnosis with other close species of this informal subgroup see Table 1 and Figs 8-19.

Cyphochilus nguyenvanvinhi **Sabatinelli & Phạm n. sp.**

Figs 14-16, 31

Holotype: IEBR; ♂; *VIETNAM, Vĩnh Phúc Province:* // North Vietnam - / Tam Dao [Đảo], 29.IV.1991 / leg. M. Fujoka & R. Muramoto (P) // Holotypus ♂ / *Cyphochilus* / *nguyenvanvinhi* n. sp. / G. Sabatinelli & P. Phạm, 2021 (T on red) //.

Paratypes: 73 specimens. *VIETNAM, Vĩnh Phúc Province*: IEBR: 1 ♀; MHNG (MHNG-ENTO-85547): 1 ♂, 3 ♀; same data as holotype – MHNG: 3 ♂; HNHM: 1 ♂; PCMN: 3 ♂; ZMUH: 10 ♂; 75 km NW from Hanoi, Tam Đảo; 15.V.-16.VI.-1991; E. Jendek leg. – SMSN: 1 ♂; same locality as previous; 20.IV.1986, 900 m. – SMSN: 1 ♀; same locality as previous; 15-17.IV.1986, 900 m – NHMB: 5 ♂, 5 ♀; Tam Đảo; 20-28.VI.1990; J. Strnad leg. – NHMB: 2 ♂, 1 ♀; same locality as previous; 5.10.VI.1989; Brantlová leg. – NMPC: 1 ♀; same locality as previous; 11.VI[?].1988[?]; J. Jelínek leg. – NMPC: 2 ♀; same locality as previous; M. Hrasdký leg. – NMPC: 2 ♂, 3 ♀; same locality as previous; 17-21.V.1990; J. Horák leg. – NHMB: 1 ♂; NMPC: 1 ♂; same locality as previous; 13-24.VI.1989; A. Olexa leg. – NHMB: 1 ♂; same locality as previous; 3-11.VI.1985; Navrátil leg. – NHMB: 1 ♂; same locality as previous; 20-27. VI.1990; A. Olexa leg. – NHMB: 1 ♂; same locality as previous; 6-9.V.1990; P. Pacholátko leg. – NHMB: 1 ♀; same locality as previous; 6-9.V.1990; P. Pacholátko leg. – PCMN: 2 ♂; same locality as previous; 20.V.1991; Křeček leg. – MNHN: 1 ♂; same locality as previous – ISNB: 1 ♂; IEBR: 4 ♂; Tam Đảo National Park; 3.VII.2003; Hoang Vu Tru leg. – IEBR, 13 ♂; same locality as previous; 27-28.V.2004, 1000 m; Hoang Vu Tru leg. – *VIETNAM, Lào Cai* Province: NHMB: 1 ♂; Sapa [Sa Pa]; 11-19.VI.1990; Brantlová leg. –

Description of the holotype male

Body: Subparallel, BL: 19.9 mm, BW: 8.6 mm, BWX: 10.7 mm situated at midpoint of elytra; dorsal and ventral integuments black, legs and appendices reddish-brown; dorsal surface with dirty-white scales more densely aggregated at the lateral margins and apex of elytra where they are yellowish.

Head: CW/L: 3.3; anterior angles of clypeus largely rounded, anterior margin straight; frons depressed, large, thus eyes relatively big (F/O: 3.4); antennal club twice longer than antennomeres 2-7 (A2-7/CL: 0.5).

Pronotum: Transverse (PnW/L: 1.9), strongly convex; anterior and basal angles right.

Elytra: With four elevated costae, in addition to sutural one, not reaching the elytral apex.

Thoracic sterna: With short, white setation and scales; mesoventrum not developed or visible between the mesocoxae.

Abdomen: Ventrites medially smooth without scales or punctures, last ventrite depressed medially.

Pygidium: Ventral surface narrow. *Legs*: protibiae tridentate with basal teeth small; the two apical teeth close to each other.

Aedeagus: Parameres with median lobe not developed (Fig. 15); right paramere distally enlarged and curved dorsally with bifid apex (Figs 14-15); left paramere much shorter than right ending in an acute point curved externally (Figs 15-16).

Male paratypes: BL: 19-23.5 mm (x = 22.7; n = 35); all specimens have same dirty-white scale vestiture as the holotype, no colour variations observed.

Female paratypes: Body ovoid larger than but not longer than in males; BL: 22.4-23.6 mm (n = 13); BW: 8.5; BWX: 11.8; antennal club ovate, shorter than preceding antennomeres 2-7 (A2-7/CL: 1.3); all specimens have same dirty-white scale vestiture as males, no colour variations observed.

Etymology: Prof. Nguyễn Văn Vịnh is a lecturer at Vietnam National University, University of Science in Hanoi, vice-head of the Faculty of Biology. As the head of the Department of Applied Zoology, he was supervisor of Phạm in his bachelor and master degrees.

He has been studying the diversity and conservation of mayflies in Vietnam since 2000.

Type locality: Tam Đảo is a rural district of Vĩnh Phúc Province in the Red River Delta region of northern Vietnam.

Distribution: Tam Đảo National Park, where probably most of the specimens were collected, is an area in northern Vietnam about 85 km northwest of Hanoi (Fig. 31). The Park is based in the Tam Đảo range, which runs 80 km from north west to south east and is one of the terminal spurs of a larger mountainous area in the Northwest region of Vietnam, and has more than 20 peaks with altitudes of over 1000 m. Due to the tall mountainous range that splits the area into two parts, the NP climatic condition is divided into two areas with different rainfalls. This difference and some other factors such as the effect of human activity divide the park into some smaller climatic zones and eight kinds of forest types, which increase the biodiversity in the park. Several species of insects are endemic to Tam Đảo area and *Cyphochilus nguyenvanvinhi* n. sp. could be one of them except for an isolated record in Sa Pa (Lào Cai Province).

Remarks: For the differential diagnosis with other close species of this informal subgroup see Table 1 and Figs 8-19.

Cyphochilus zianii Sabatinelli & Phạm n. sp.

Figs 17-19, 31

Holotype: IEBR; ♂; *LAOS, Xiangkhouang Province* // NE Laos, 1500 m / Xing Khang [Xiangkhouang], 20.V.1996 (P) // Holotypus ♂ / *Cyphochilus* / *zianii* n. sp. / G. Sabatinelli & P. Phạm, 2021 (T on red) //.

Paratypes: 52 specimens. *LAOS, Xiangkhouang Province*: MHNG, 1 ♂, 1 ♀; Xiangkhouang Plateau; [19.6093° N, 103.7289° E], 1500 m; 20.V.1996; local collector – *Phôngsali Province*: NHMB: 8 ♂, 3 ♀; MHNG (MHNG-ENTO-85548, 85549) 1 ♂, 1 ♀; Phôngsali env.; 21°41-2'N 102°06-8'E, ~1500 m, 28.V.-20.VI.2003; M. Brancucci leg. – NMPC: 3 ♂, 1 ♀; same data as previous; V. Kubáň leg. – NMPC: 1 ♂, 5 ♀; same locality as previous; 6-17.V.2004; V. Kubáň leg. – *VIETNAM, Sơn La Province*: IEBR: 1 ♂; Thuận Châu, Copia Nature Reserve; [21.3901° N, 103.6363° E] 7.VI.2008; Le Xuan Hue leg.– IEBR: 7 ♂; same locality as previous; 28.IV-2.V.2016, 1500 m; Hoang Vu Tru leg. – *Hòa Bình Province*: IEBR: 2 ♂; Mai Châu District, Hang Kia-Pa Co Nature Reserve; [20.6901° N, 105.0090° E] 19-28.IV.2002, 1100-1200 m; Hoang Vu Tru leg. – *Lào Cai Province*: NHMW: 1 ♂; WNW Sa Pa, Tram Ton pass; 22°21'09"N 103°46'28.6"E, ~1900 m; 22.VI.2017; Vietnam expedition 2017 NHMW, CNC, H. Schillhammer, R. Schuh, D. Zimmermann, A. Brunke, H. Douglas leg. – ISNB: 2 ♂; Lào Cai; 1920; Vitalis de Salvaza & Madame A. Vuillet [leg] – ISNB: 1 ♂; Chapo [Sa Pa, ca. 22°20'N 103°50'E]; Vitalis de Salvaza leg. – *Bắc Kạn Province*: HNHM: 1 ♂; Ba Be National Park, Na Mam forest; 22.417137°N 105.632505°E, 200 m; 17-19.IV.2010, at light, VN2020PL_17; L. Papp, L. Peregovits & Z. Soltész leg. – NHMB: 4 ♂, 4 ♀; same locality as previous; 6-17.V.2004; M. Brancucci leg. – NHMB: 1 ♂, 1 ♀, Ban Sano Mai; [21.3466° N, 102.0511° E] ~1150 m; 19-26.V.2004; M. Brancucci leg. – *TONKIN* without other information: ISNB: 2 ♂; sub *ochraceosquamosus* Moser; coll. R. Ley.

Description of the holotype male

Body: Subparallel, BL: 20.8 mm, BW: 9.2 mm, BWX: 11 mm situated at midpoint of elytra; dorsal and ventral integuments black, legs and appendices reddish-brown; dorsal surface with white-yellowish scales more densely aggregated at the lateral margins and apex of elytra where they are yellowish.

Head: CW/L: 3.2; anterior angles of clypeus largely rounded, anterior margin straight; frons depressed, large, thus eyes relatively big (F/O: 3.6); antennal club twice longer than antennomeres 2-7 (A2-7/CL: 0.5).

Pronotum: Transverse (PnW/L: 2.1), strongly convex; anterior angles acute, basal angles obtuse.

Elytra: With four elevated costae, in addition to sutural one, not reaching the elytral apex.

Thoracic sterna: With short, white setation and scales; mesoventrum not developed or visible between the mesocoxae.

Abdomen: Ventrites medially smooth without scales or punctures, last ventrite depressed medially.

Pygidium: Ventral surface narrow.

Legs: protibiae tridentate with basal teeth small; the two apical teeth close to each other.

Aedeagus: Parameres with median lobe not developed (Fig. 18); right paramere distally enlarged and curved dorsally truncate at apex (Figs 17-18); left paramere much shorter than right ending in an acute point curved externally (Figs 18-19).

Male paratypes: BL: 19-22.5 mm (x = 21.3; n = 19); most of specimens have the same white-yellowish scale vestiture as the holotype with the exception of two specimens from Sa Pa (Vietnam) with brown scale vestiture similar to some specimens of *C. brancuccii* n. sp.

Female paratypes: Body ovoid generally bigger than in males; BL: 20.5-24.2 mm (n = 9); BW: 9.6; BWX: 12; antennal club ovate, shorter than preceding antennomeres 2-7 (A2-7/CL: 1.2); all specimens have the same dirty-white scale vestiture as the holotype and denser in some specimens.

Etymology: Stefano Ziani is a reputed specialist of coprophagous Scarabaeidae, a good friend and

a valuable advisor on the complicated matters of taxonomy.

Type locality: Xiangkhouang Province is characterized by rolling hills and grassland whose elevation ranges between 336 and 2257 m. The province borders Luang Prabang Province to the northwest, Houaphanh Province to the northeast, Vietnam to the east, Bolikhamsai Province to the southeast, and Vientiane Province to the southwest. It maintains a National Biodiversity Conservation Area with a high level of biodiversity and protecting a number of endangered species.

Distribution: *Cyphochilus zianii* n. sp. has a relatively large distribution in northeast Laos: Xiangkhouang and Phôngsali Provinces, and in northern Vietnam: Sơn La, Hòa Bình, Lào Cai, and Bắc Kạn Provinces (Fig. 31).

Remarks: Some specimens from Sa Pa (Lào Cai Province) have the right paramere sinuate instead of straight. For this reason, they are excluded from the type series of *C. zianii* since the meaning of such morphological differences needs to be better investigated with additional sampling. For the differential diagnosis with other close species of this informal subgroup see Table 1 and Figs 8-19.

Cluster C

Species with median part of ventrites with scales, if scales were rubbed off, punctures are present; parameres subtriangular in lateral view with apical part thin, right paramere bearing on its dorsal margin a thorn-like process directed externally (Figs 20-28). This group includes *Cyphochilus keithi* n. sp., *C. nguyendui* n. sp., *C. phamthinhiae* n. sp which can be easily distinguished by the parameres morphology which is very distinctive for each species (Figs 20-28).

Cyphochilus keithi Sabatinelli n. sp.

Figs 20-22, 32

Holotype ♂: MHNG (MHNG-ENTO-85541); *MYANMAR* // Myanmar, 21.V.98 [1998] / Putao [Puta-O], 65 km NW / 1250 m ZiYarDam [Ziyardam, 27.3182N, 97.4057E] / Murzin & Siniaev leg. (P) // Holotypus ♂ / *Cyphochilus* / *keithi* n. sp. / G. Sabatinelli, 2021 (T on red) //.

Paratypes: 1 specimen. PCDK: 1 ♂; same data as the holotype.

Description of the holotype male

Body: Subparallel, BL: 18.7 mm, BW: 8.2 mm, BWX: 10.2 mm situated at midpoint of elytra; dorsal and ventral integuments black, legs and appendices reddish-brown; dorsal surface with white-yellowish scales more densely aggregated at the lateral margins and apex of elytra where they are yellowish.
Head: CW/L: 3.3; anterior angles of clypeus largely rounded, anterior margin straight; frons depressed, large, thus eyes relatively small (F/O: 5); antennal club twice longer than antennomeres 2-7 (A2-7/CL: 0.4).
Pronotum: Transverse (PnW/L: 2.2), strongly convex; anterior angles acute, basal angles obtuse.
Elytra: With four elevated costae, in addition to sutural one, not reaching the elatral apex.
Thoracic sterna: With short, white setation and scales; mesoventrum not developed or visible between the mesocoxae.
Abdomen: Ventrites medially smooth without scales or punctures, last ventrite depressed medially.
Pygidium: Ventral surface narrow.
Legs: Protibiae tridentate with basal teeth small; the two apical teeth close to each other.
Aedeagus: Parameres with median lobe not developed (Fig. 21); right paramere on dorsal margin with a small thorn-like process directed externally (Figs 20-21); left paramere slightly shorter than right narrowed distally (Figs 21-22).

Male paratype: BL: 19 mm; without substantial morphological differences from the holotype.

Etymology: Denis Keith is a friend and entomologist who published several works on Scarabaeidae of Southeast Asia and kindly provided the specimens for this study.

Type locality: Ziyardam, the last village to the North West of Myanmar, is home to the Rawang tribe; it is situated in the Phonganrazi National Park (Fig. 32), where there are present rare species of flora and fauna in a conservation area of endangered species.

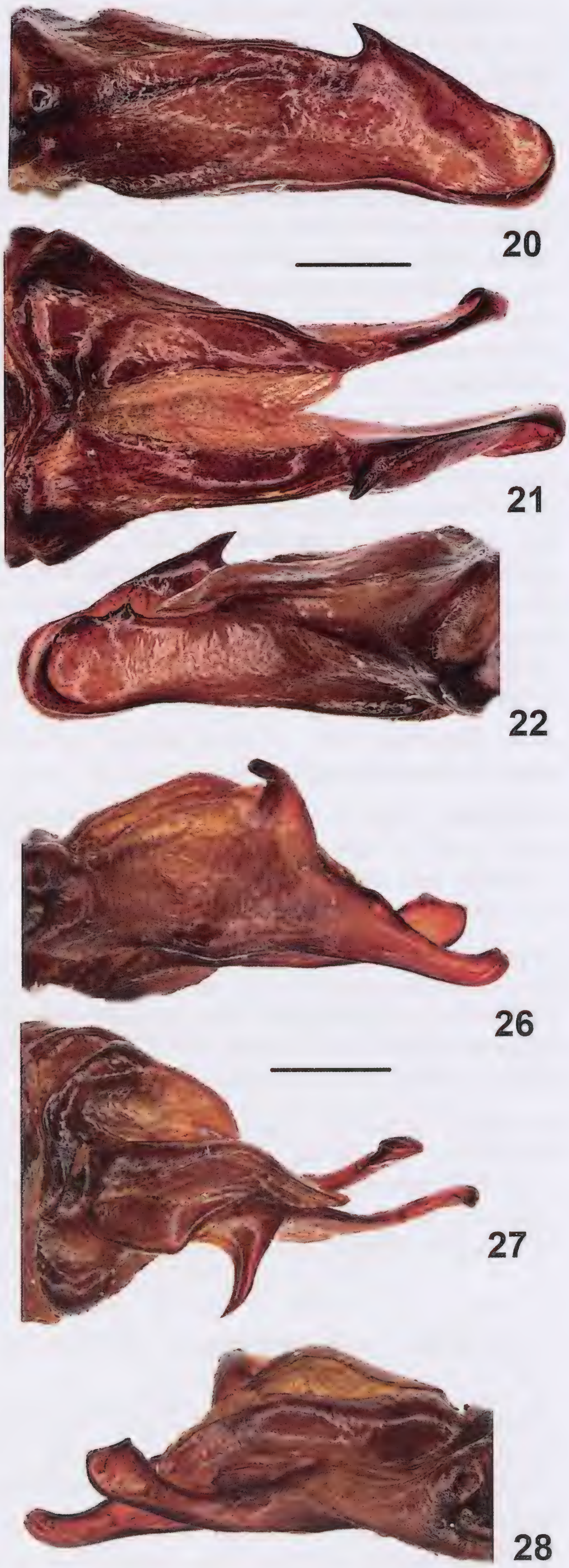
Remarks: *Cyphochilus keithi* n. sp. is morphologically similar to *C. nguyendui* n. sp. and *C. phamthinhiae* n. sp from which it can be easily distinguished by the parameres morphology which is very distinctive for each species (Figs 20-28).

Cyphochilus nguyendui Sabatinelli & Phạm n. sp.

Figs 23-25, 29, 32

Holotype: IEBR; ♂: *VIETNAM, Lào Cai Province* // NW Vietnam Sapa [Sa Pa] / Hoàng Liên Sơn / near Lao Kay [Lào Cai] (P) // Holotypus ♂ / *Cyphochilus* / *nguyendui* n. sp. / G. Sabatinelli & P. Phạm des. (T on red) //.

Paratypes: 150 specimens. *VIETNAM: Lào Cai Province:* MHNG (MHNG-ENTO-85544, 85545): 3 ♂, 2 ♀; same data as holotype. – IEBR: 7 ♂; Sa Pa, Hoàng Liên National Park; 19.VI.2002; Hoang Vu Tru leg. – PCAR: 2 ♂; same locality as previous, 22°22.780'N 103°47.640'E, 2050 m; A. Weigel leg. – IEBR: 1 ♂;



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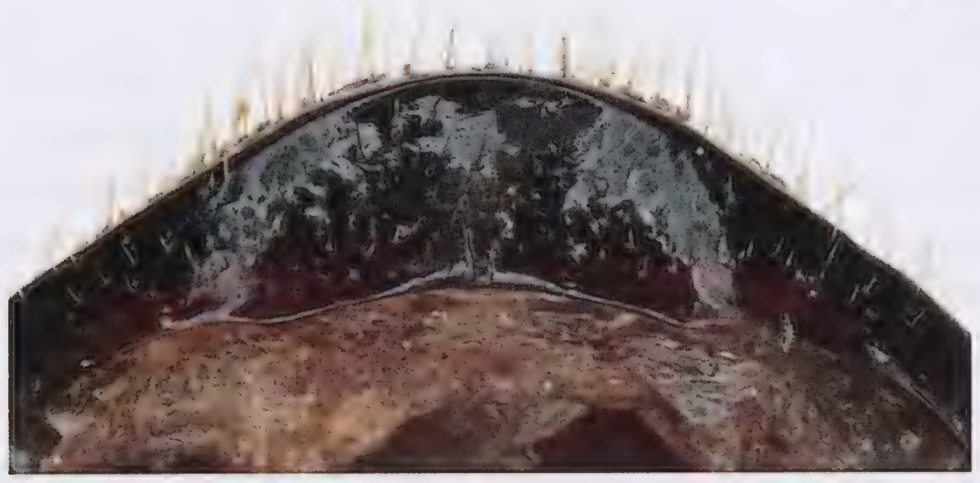

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Figs 20-30. Paramera in right (apex to the right), dorsal (apex to the right) and left (apex to the left) view: (20-22) *Cyphochilus keithi* n. sp., holotype; (23-25) *C. nguyendui* n. sp., holotype; (26-28) *C. phamthinhiae* n. sp., holotype. Ventral portion of pygidium: (29) *C. nguyendui* n. sp.; (30) *C. phamthinhiae* n. sp. Scale bars = 0.5 mm.

same locality as previous; 17.V.2003, 1800 m; Hoang Vu Tru leg. – IEBR: 1 ♂; same locality as previous; Cát Cát Village, 1300 m; 16.V.2003; Hoang Vu Tru leg. – IEBR: 1 ♂; same locality as previous; 1830 m; 5.V.2013; Hoang Vu Tru leg. – PCMN: 1 ♂; same locality as previous; 12.V.1990; P. Pacholátko leg. – NHMB: 3 ♂; same locality as previous; 11-15.V.1990; V. Kubàn leg. – PCAR: 2 ♂; Hoàng Liên National Park, Sa Pa pass, 1900 m; 27.V.-2.VI.2011; L. Bartolozzi leg. – PCMN: 1 ♂; Sa Pa, 22°20'N 103°50'E; 25.V.-10.VI.1991; E. Jendek leg. – HNHM: 13 ♂, 6 ♀; Hoàng Liên NP, Trạm Tôn, forest edge at light, 22.34937°N 103.77045°E, 1915 m; 8-11.IV.2010; L. Papp, L. Peregovits, Z. Soltész & G. Lengyel leg. – MHNW: 11 ♂; NW Sa Pa, 200 m SW Trạm Tôn pass, 22°21'40"N 103°46'24"E, ~1900 m; 24.VI.2017; Vietnam Expedition 2017 MHNW CNC, H. Schillhammer, R. Schuh, D. Zimmermann, A. Brunke, H. Douglas leg. – MZUF: 2 ♂; Văn Bàn distr., Văn Bàn Nature Reserve, at light, ~1000 m; 23-26.V.2011; L. Bartolozzi, S. Bambi, F. Fabiano, E. Orbach leg. – MZUF: 6 ♂: Hoàng Liên Nat. Park, ~Sa Pa pass, at light; ~1900 m; 25.V.-2.VI.2011; L. Bartolozzi, S. Bambi, F. Fabiano, E. Orbach leg. – MHNG: 13 ♂, 1 ♀; Sa Pa distr. Hoàng Liên Nat. Park; 1900 m; 27-31.V.2011; E. Orbach leg. – ISNB; 1 ♂; Lao Kai [Lào Cai]; 1920; Vitalis de Salvaza [leg.], M. A. Vuillet. – ISNB: 1 ♂; Chapa [Sa Pa]; 25.V.1916; Vitalis de Salvaza [leg.]; Typus [without any species name] – *Cao Bằng Province:* PCAR: 1 ♂; Vin. Don Nui Pia Oac [Phia Oắc Mountain] Nature Res., 22°23'52"N 105°52'53"E, 900-1350; 15.V.2014; A. Skale leg. – *LAOS: Houaphan Province:* NMPC: 4 ♂, 1 ♀; Ban Saleuï, Phu Phan Mt.; 20°15'N 104°02'E, 1500-2000 m; 26.IV.11.V.2001; J. Bezděk leg. – NMPC: 1 ♂; Ban Saleuï, 30 km S of Xam-Neua [Sam-Neua]; 20°13'39"N 103°59'33"E, 1500 m; 1-17.V.2004; P. Kresl leg. – NMPC: 1 ♂; Ban Saleuï, Phu Phan; 20°12-13.5'N 103°59.5'-104°01'E, 1340-1870 m; 15-IV-15.V.2008; local collector. – NMPC: 3 ♂; same locality as previous; 20°13'N 103°59'E, 1300-2000 m; 6-18.IV.2004; J. Bezděk leg. – NHMB: 1 ♂, 4 ♀; NMPC: 9 ♂; Phou Pane Mt. [Phu Phan Mt.]; 20°13'09"N 103°59'54"-104°00'03"E, 1480-1550 m; 1-16.VI.2009; NHM Basel, NMPC Prague, Laos 2009 Expedition, M. Brancucci, M. Geiser, Z. Kraus, D. Hauck and V. Kubáň leg. – NMPC: 2 ♂, 3 ♀; IECA: 4 ♂; same locality as previous; 22.IV.-14.V.2008; V. Kubáň leg. – PCAR: 2 ♂, 1 ♀; Phu Pan [Phu Phan]; 20°11'N 104°01'E, 1730 m; 10.IV.2004; M. Hasegawa leg. – NMPC: 3 ♂, 2 ♀; Phou Pane Mt. [Phu Phan Mt.]; 20°12.328'N 103°00.621', ~1750 m; 15.V.-3.VI.2007; V. Kubáň leg. – PCMN: 1 ♂, 1♀; NMPC: 1 ♂; same locality as previous; 20°15'N 104°02'E, 1500-2000 m; 26.IV.-11.V.2001; D. Hauck leg. – IECA: 4 ♂, 3♀; same data as previous – ZMHB: 12 ♂, 8 ♀; same locality as previous; 20°12'N 104°01'E, 1300-1900 m; 11.IV.-15.V.2012; C. Holzschuh leg.

Description of the holotype male

Body: Subparallel, BL: 19.7 mm, BW: 7.8 mm, BWX: 10 mm situated at midpoint of elytra; dorsal and ventral integuments black, legs and appendices reddish-brown; dorsal surface with yellowish scales more densely aggregated at the lateral margins and apex of elytra where they are yellowish.

Head: CW/L: 3.2; anterior angles of clypeus largely rounded, anterior margin straight; frons depressed, large, thus eyes relatively small (F/O: 5.1); antennal

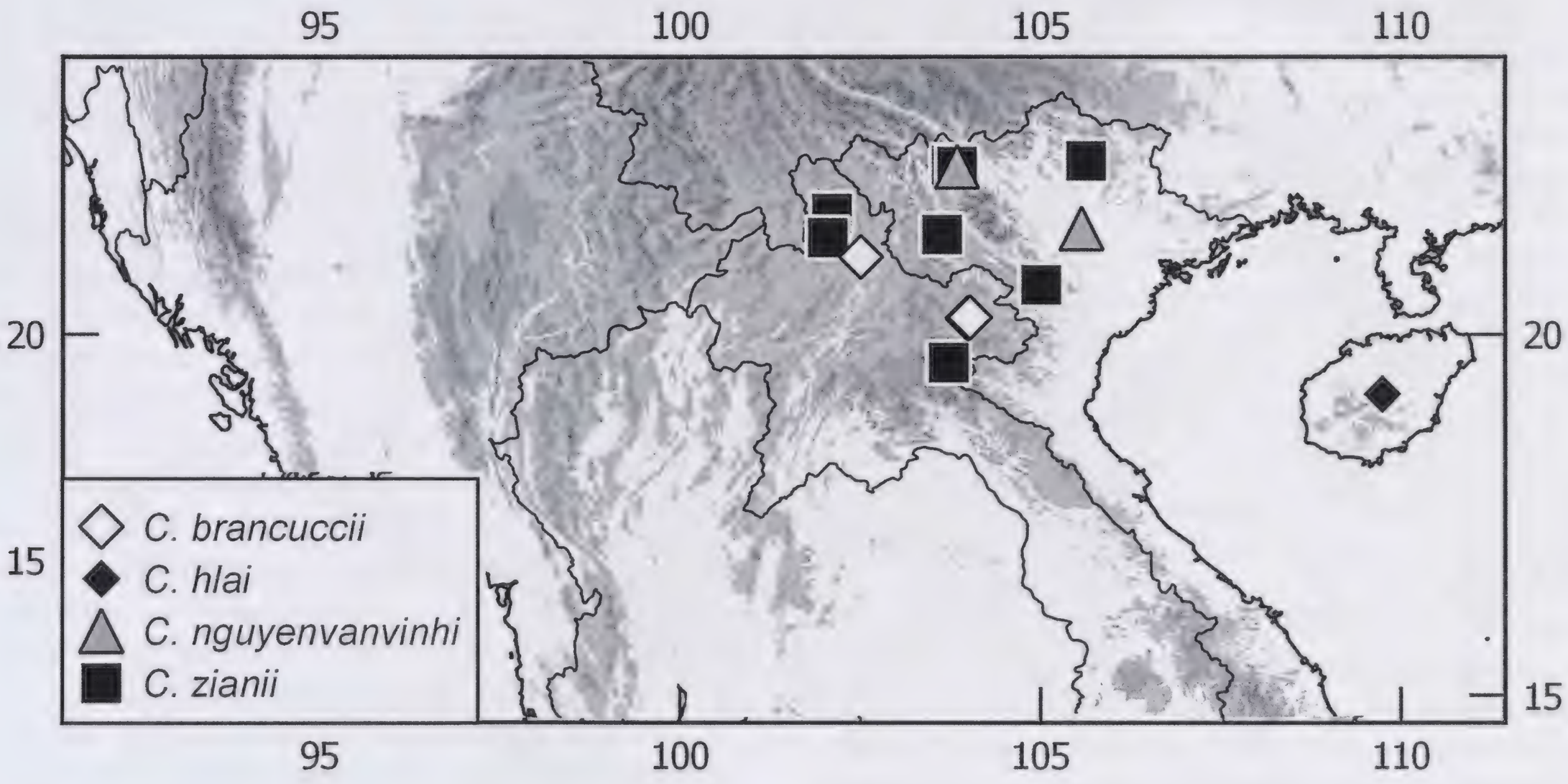

Fig. 31. Geographical distribution of *Cyphochilus brancuccii* n. sp., *C. hlai* n. sp., *C. nguyenvanvinhi* n. sp. and *C. zianii* n. sp.

club bent externally twice longer than antennomeres 2-7 (A2-7/CL: 0.4).
Pronotum: Transverse (PnW/L: 2), strongly convex; anterior angles acute, basal obtuse.
Elytra: With four elevated costae, in addition to sutural one, not reaching the elytral apex.
Thoracic sterna: With short, white setation and scales; mesoventrum not developed or visible between the mesocoxae.
Abdomen: Ventrites medially smooth without scales or punctures, last ventrite depressed medially.
Pygidium: Ventral surface narrow.
Legs: Protibiae tridentate with basal teeth small; the two apical teeth close to each other.
Aedeagus: Parameres with median lobe not developed (Fig. 24); right paramere on dorsal margin with a big thorn-like process directed externally (Figs 23-24); left paramere slightly shorter than right narrowed distally (Figs 24-25).

Male paratypes: BL: 18.4-20.6 mm (x = 19.8, n = 44). Half of the male specimens have the colour of scale vestiture of the upper part of the body dirty-white instead of yellowish as in the holotype.

Female paratypes: Body ovate larger than males; BL: 19.8-22.1 mm (x = 21.8, n = 35); BW: 8.7; BWX: 11.7; antennal club ovate, short (A2-7/CL: 0.9). In the female specimens, the colour of scale vestiture of the upper part of the body is more snow-white than in the males, some specimens also have yellowish scales.

Etymology: Nguyễn Du is a celebrated Vietnamese poet, from the 19th century, called "poet laureate" by Vietnamese and honoured as "World Cultural Celebrity" by UNESCO in 2013 for his influence in the cultural history of Vietnam and the whole region.

Type locality: Sa Pa or Sapa, is a district-level town of Lào Cai Province in northwest Vietnam, 380 km northwest of Hanoi close to the border with China. The Hoàng Liên Son range of mountains dominates the district, which is at the eastern extremity of the Himalayas.

Distribution: *Cyphochilus nguyendui* n. sp. along with *C. brancuccii* n. sp. is one of the most common *Cyphochilus* species collected in North Vietnam (Lào Cai and Cao Bằng Provinces) and Laos (Houaphan Province) (Fig. 32).

Remarks: *Cyphochilus nguyendui* n. sp. is morphologically similar to *C. phamthinhiae* n. sp. from which it can be easily distinguished by the morphology of the right paramere, which is much smaller at the base in lateral projection (Figs 23 versus 26). The ventral apical margin of pygidium in *C. phamthinhiae* n. sp. is bearing two small pointed apophyses absent in *C. nguyendui* (Figs 30 versus 29).

Cyphochilus phamthinhiae Sabatinelli & Phạm n. sp.

Figs 26-28, 30, 32

Holotype: IEBR; ♂; *VIETNAM, Vĩnh Phúc Province*: // N. Vietnam / Tam Dao [Tam Đảo] / 10-20.V.1993 (P) // Holotypus ♂ / *Cyphochilus* / *phamthinhiae* n. sp. / G. Sabatinelli & P. Phạm des. (T on red) //.

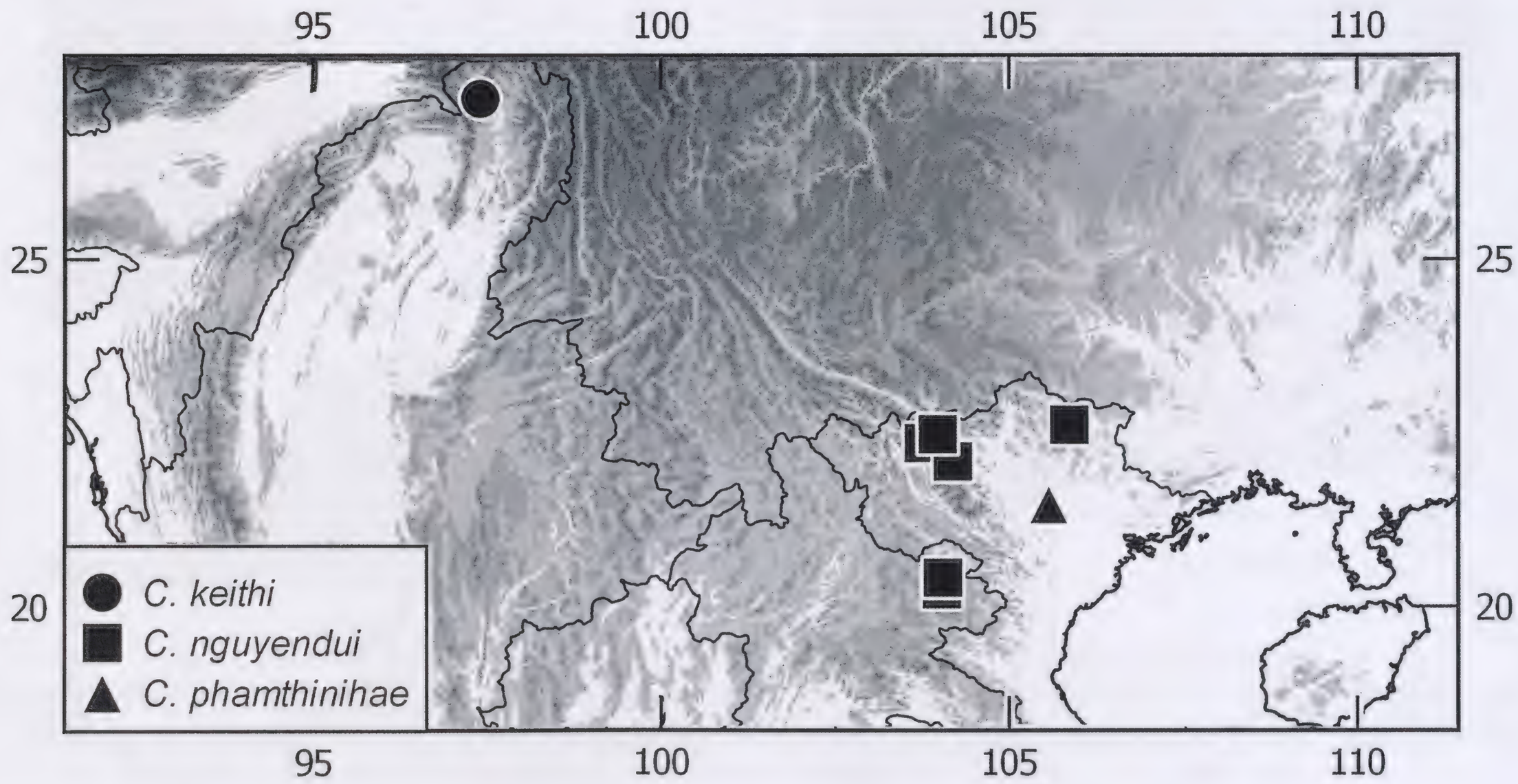

Fig. 32. Geographical distribution of *Cyphochilus keithi* n. sp., *C. nguyendui* n. sp. and *C. phamthinhiae* n. sp.

Paratypes: 54 specimens. *VIETNAM: Vĩnh Phúc Province*: IEBR: 7 ♂; Tam Đảo, Tam Đảo National Park; 22-28.V.2004; 1000 m; Hoang Vu Tru leg. – IEBR: 2 ♂; same locality as previous; 2-4.V.2013; Hoang Vu Tru leg. – PCMN: 2 ♂, 1 ♀; ZMHB: 3 ♂; MHNG (MHNG-ENTO-85542, 85543): 2 ♂; Tam Đảo, 75 km from Hanoi; 15.V.-16.VI.1991; E. Jendek leg. – NHMB: 4 ♂; Tam Đảo; 17-21.V-1990; P. Pacholátko leg. – NHMB: 1 ♂, 1 ♀; PCMN: 3 ♂; NMPC: 3 ♂; same locality as previous; 6-9.V-1990; V. Kubáň leg. – MHNW: 2 ♂, 1♀; NMPC: 1 ♂, 1 ♀; same locality as previous; 25.V.-2.VI.1986; J. Rybníček leg. – NHMB: 2 ♂, 3 ♀; same locality as previous; 20-28.VI.1990, J. Strnad leg. – MHNW: 1 ♂; same locality as previous; 16-23.V.1991; J. Strnad leg. – PCAR: 1 ♂; same locality as previous; 950 m; 1995; local collector. – NHMB: 1 ♂, 1 ♀; same locality as previous; 20-27.VI.1990; A. Olexa leg. – NMPC: 1 ♂; same locality as previous; 900 m; 13-24.V.1989; A. Olexa leg. – MHNG: 1 ♂; same locality as previous; 6-23.V.1990; B. Makovský leg. – NHMB: 2 ♂; NMPC: 1 ♂; same locality as previous; 3-11.VI.1985; J. Picka leg. – NHMB: 1 ♂; same locality as previous; V.1990; J. Picka leg. – NHMB: 1 ♂; same data as previous; Navrátil leg. – NMPC: 3 ♂; same locality as previous but without date; M. Hrasdký leg. – NMPC: 1 ♂; same locality as previous; 900-1400 m; 6-11.VI.1985; J. Jelínek leg.

Description of the holotype male

Body: Subparallel, BL: 19.5 mm, BW: 8.3 mm, BWX: 10.6 mm situated at midpoint of elytra; dorsal and ventral integuments black, legs and appendices reddish-brown; dorsal surface with white scales more densely aggregated at the lateral margins and apex of elytra where they are yellowish.

Head: CW/L: 3; anterior angles of clypeus largely rounded, anterior margin straight; frons depressed, large, thus eyes relatively big (F/O: 3.3); antennal club bent externally longer than antennomeres 2-7 (A2-7/CL: 0.3).

Pronotum: Transverse (PnW/L: 2), strongly convex; anterior angles acute, basal angles obtuse.

Elytra: With four elevated costae, in addition to sutural one, not reaching the elytral apex. *Thoracic sterna*: with short, white setation and scales; mesoventrum not developed or visible between the mesocoxae. *Abdomen*: ventrites medially smooth without scales or punctures, last ventrite depressed medially.

Pygidium: Ventral surface narrow.

Legs: Protibiae tridentate with basal teeth small; the two apical teeth close to each other.

Aedeagus: Parameres with median lobe not developed (Fig. 27); right paramere on dorsal margin with a big thorn-like process directed externally (Figs 26-27); left paramere slightly shorter than right and narrowed distally (Figs 27-28).

Male paratypes: BL: 18.8-20.4 mm (x = 19.4, n = 22). All specimens have same white scale vestiture of the upper part of the body as in the holotype.

Female paratypes: Body ovate larger than males; BL: 18.2-22.1 mm (x = 20.8, n = 15); BW: 9; BWX: 11.8; antennal club ovate, shorter than preceding antennomeres 2-7 (A2-7/CL: 1.3). In the female specimens, the colour of scale vestiture of the upper part of the body is more snow-white than in the males.

Etymology: Dr Phạm Thị Nhị is an entomologist and the head of the Department of Insect Systematics at IEBR. She received her doctoral degree from Bonn University, Germany, and for many years has instructed and inspired many young entomologists in Vietnam, including the second author (PP).

Type locality: Tam Đảo. See above the description of *Cyphochilus nguyenvanvinhi* n. sp. for details about Tam Đảo locality.

Distribution: *Cyphochilus phamthinhiae* n. sp. is known only from Tam Đảo in the Vĩnh Phúc Province and along with C. *nguyenvanvinhi* n. sp. is another example of endemism of this interesting location (Fig. 32).

Remarks: *Cyphochilus phamthinhiae* n. sp. is morphologically similar to *C. nguyendui* n. sp. from which can be easily distinguished by the morphology of the right paramere which is much larger at the base in lateral projection (Figs 26 versus 23). Also the ventral apical margin of pygidium in *C. phamthinhiae* n. sp. is bearing two small pointed apophyses absent in *C. nguyendui* (Figs 30 versus 29).

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We would like to thank the following curators of the Museums and Colleagues for the loan of the specimens and for their patience in responding to the requests and delays in returning the material: Aleš Bezděk (IECA), Konjev Desender, Marcel Cludts and Alain Drumont (ISNB), Jiří Hájek (NMPC), Ottó Merkl (HNHM), Olivier Montreuil (MNHN), Milan Nikodým (Prague, Czech Republic), Andreas Reichenbach (Leipzig, Germany), Matthias Seidel (ZMUH), Harald Schillhammer and the late Heinrich Schönmann (NHMW), Manfred Uhlig, Joachim Schulze, Johannes Frisch and Bernd Jaeger (ZMHB), Isabelle Zuercher and Christoph Germann (NHMB). We are grateful to Pham Thi Nhi (IEBR) for her encouragement and facilitation in studying the specimens kindly collected by Hoang Vu Tru (IEBR). We thank Giulio Cuccodoro (MHNG) for his advice on taxonomical issues, Dirk Ahrens for preparing the distribution map, David Carlson, Denis Keith and Stefano Ziani for reviewing the manuscript. This work has been financially supported by IEBR project number DT.6-21.

REFERENCES

Arrow G. J. 1938. Notes on some Melolonthine Coleoptera from the Malay Peninsula and descriptions of a few new species. *Journal of the Federated Malay States Museums* 18: 267-278.

Arrow G. J. 1941. Entomological results from the Swedish expedition 1934 to Burma and British India (Coleoptera: Melolonthidae). *Arkiv für Zoologi* 33A(8): 1-8.

Bezdek A. 2016. Scarabaeidae, subfamily Melolonthinae, tribe Leucopholini (pp. 224-226). *In:* Löbl I. & Löbl D. (eds), Catalogue of Palaearctic Coleoptera. Volume 3. Scarabaeoidea – Scirtoidea – Dascilloidea – Buprestoidea – Byrrhoidea. Revised and updated edition. *Brill, Leiden-Boston*, 984 pp.

Brenske E. 1903. Neue Arten der Melolonthiden (Coleopt.) Gattung *Cyphochilus*. *Insekten Börse* 20: 380-381.

Dalla Torre K. W. von. 1912. Fam. Scarabaeidae, Subfam. Melolonthidae. *In:* Junk W. & Schenkling S. (eds), Coleopterorum Catalogus. Vol. XX, pars 49. *W. Junk, Berlin:* 450 pp.

Evenhuis N.L. 2007. The insect and spider collections of the world website. Available at: *http://hbs.bishopmuseum.org/codens/* [Last accessed: 1st December 2019].

Fairmaire L. 1902. Descriptions de Coléoptères recueillis en Chine par M. de Latouche. *Annales de la Société entomologique de France* 1902: 316-318.

Frey G. 1971. Neue Ruteliden und Melolonthiden aus Indien und Indochina. *Entomologische Arbeiten aus dem Museum G. Frey* 22: 109-133.

Krajčik M. 2012. Checklist of the World Scarabaeoidea. *Animma.x, supplement 5. Plzen, Czech Republic,* 278 pp.

Li C. & Yang P. 1999. Revision of the genus *Malaisius* Arrow (Coleoptera: Scarabaeidae: Melolonthinae). *The Canadian Entomologist* 131(2): 187-202.

Löbl I. & Smetana A. 2006. Distributional Information (pp. 11-15). *In:* Löbl I. & Smetana A. (eds), Catalogue of Palaearctic Coleoptera. Volume 3. Scarabaeoidea - Scirtoidea - Dascilloidea - Buprestoidea - Byrrhoidea. *Apollo Books, Stenstrup,* [1-6] + 7-690 pp.

Medvedev S. I. 1951. Plastinchatousye (Scarabaeidae), posdem. Melolonthinae, ch. 1 (chrushchi). Fauna SSSR, zhestkokrylye. Tom. 10, vyp. 1. *Moskva, Leningrad: Izd. Akad. Nauk. SSSR* 512 pp.

Moser J. 1915. Beitrag zur Kenntnis der Melolonthiden (Col.) IV. *Deutsche Entomologische Zeitschrift* 1915: 113-151.

Nomura S. 1977. On the Melolonthini of Taiwan (Coleoptera, Scarabaeidae). *Tôhô-Gakuhô* 27: 85-109.

Nonfried A. F. 1893. Beiträge zur Käferfauna von Manipur (Vorderindien). *Berliner entomologische Zeitschrift* 38: 327-340.

Olivier G.A. 1789. Entomologie, ou Histoire naturelle des insectes, avec leurs caractères génériques et spécifiques, leur description, leur synonymie et leurs figures enluminées. Coléoptères. Tome premier. *Baudoin, Paris*: xx + 497 pp., 65 pls. [genera paginated separately].

Sabatinelli G. 2020a. Taxonomic notes on the genus *Cyphochilus* Waterhouse 1867 (Coleoptera, Scarabaeoidea, Melolonthinae) with description of 10 new species. *Revue suisse de Zoologie* 127: 157-181.

Sabatinelli G. 2020b. Taxonomic notes on the genus *Cyphochilus* Waterhouse 1867 (Coleoptera, Scarabaeoidea, Melolonthinae) (part 2) with description of nine new species and a new subspecies. *Munis Entomology & Zoology* 15: 301-318.

Sabatinelli G. 2020c. Taxonomic notes on the genus *Cyphochilus* Waterhouse 1867 (Coleoptera, Scarabaeoidea, Melolonthinae) (part 3) with description of three new species and a new subspecies. *Acta Societatis Zoologicae Bohemicae* 84: 51-65.

Sabatinelli G., Pontuale G. 1998. Description of the new genus *Dedalopterus* and notes on genus *Malaisius* Arrow and *Cyphochilus* Waterhouse. *Lambillionea* 98(1): 60-76

Sharp D. 1876. Description of some new species of Scarabaeidae from tropical Asia and Malaisia. Part III (Melolonthini). *Coleopterologische Hefte* 15: 65-90.

Torre-Bueno J. R., Tulloch G. S., Schuh R. T. 1989. The Torre-Bueno Glossary of Entomology. *New York Entomological Society:* 840 pp.

Waterhouse C.O. 1867. On some new lamellicorn beetles belonging to the family Melolonthidae. *The Entomologist's Monthly Magazine* 4: 141-146.

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Scaphisomatini of Arizona (Coleoptera, Staphylinidae, Scaphidiinae) collected by V-Flight Intercept Traps

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Abstract: Records are given for 15 Scaphisomatini species captured by V-flight intercept traps in Arizona. *Baeocera hamata* Löbl & Stephan, *B. nana* Casey and *Toxidium gammaroides* LeConte are recorded for the first time from Arizona, *B. arizonensis* sp. nov., *B. obscura* sp. nov. *B. vintercepta* sp. nov. and *Scaphisoma declivum* sp. nov. are described as new. *Scaphisoma dakotanum* Fall is synonymized with *S. desertorum* Casey. The aedeagi of *Scaphisoma desertorum* Casey, *S. rufulum* LeConte, and *S. rubens* Casey are illustrated for the first time. A key to the Arizona species of *Scaphisoma* Leach is provided. A new iteration of the V-flight intercept trap is described and the diversity of Arizona Scaphisomatini is discussed.

Keywords: Insects - shining fungus beetles - new species - records - new efficient trap - USA.

INTRODUCTION

Arizona is a biogeographically very heterogenous area, consisting of deserts, high mountains, and riverine habitats. The ranges of some Neotropical biota have their northern edges in a narrow band mostly within about 100 km north of the state's southern border. Though relatively intensively collected, complete knowledge of the Arizona beetle fauna is lacking, and most groups are poorly documented. Thus, the catalogues of Leng (1920) with the subsequent supplements (Leng & Mutchler, 1927; Blackwelder, 1939) remain sources of information for many groups, however outdated these catalogues may be. This is true also for the rove beetle subfamily Scaphidiinae Latreille, 1806, which is only partly revised for North America (Newton *et al.*, 2001). While several modern authors significantly contributed to the knowledge of the biology, associated hosts, and larvae of scaphidiines (Ashe, 1984; Hanley, 1996; Lawrence & Newton, 1980; Leschen, 1988, 1994; Leschen *et al.*, 1990; Newton, 1984, 1991; Stephenson *et al.*, 1994), modern taxonomic work on species occurring north of Mexico is limited to the description of *Scaphisoma americanum* (Löbl, 1987), the review of the *Scaphisoma* of the Ozark Highland (Leschen *et al.*, 1990), and revision of *Baeocera* Erichson, 1845 (as *Eubaeocera* new genus in Cornell, 1967, as *Sciatrophes* Blackburn, 1903 in Löbl, 1976; Löbl & Stephan, 1993). Of these, the three papers on *Baeocera* provided information on species occurring in Arizona.

Scaphisomatini can be very abundant when collected from their host fungi and sifted in leaf litter, including moist accumulations occurring in dry arroyos. They may also be collected in abundance using mass-trapping methods, with each collecting method producing different species assemblies (e.g. Ferro *et al.*, 2012), even though there is overlap. In this paper we record 15 species (four new) collected by WBW by V-form flight intercept traps (V-FIT). We describe the V-FIT, present new state records and provide a discussion about future research and the importance of implementing multiple collecting techniques for exploring further the Scaphisomatini diversity in Arizona.

MATERIAL AND TECHNIQUES

The material studied is housed in the following collections:

MCZ: Museum of Comparative Zoology, Harvard University, Cambridge, MA, USA
MHNG: Muséum d'histoire naturelle, Genève, Switzerland

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NMNH: National Museum of Natural History, Washington, DC, USA
WBWC: Private collection of William B. Warner, Chandler, AZ, USA (deposited eventually in the Arizona State University collection, Tempe, AZ, USA)

The locality data of the type material are reproduced verbatim, dates from different labels are separated by a slash. This information is not repeated under the data of the non-typical material in the sections "Material examined". The body-length is measured from the anterior pronotal margin to the posterior inner angles of elytra. The length/width ratios of the antennomeres are measured on slide-mounted antennae. The sides of the aedeagi refer to their morphological side with the ostium situated dorsally, while it is in resting position rotated 90°. The dissected body-parts are embedded in Euparal and fixed on a separate card on the same pin as the respective specimen.
For the primary references to all taxa mentioned in the present paper see Löbl (2018), for the terminology see Leschen & Löbl (2005).
The Arizona specimens that form the basis of this study were collected by WBW in a new iteration of the V-form flight intercept trap (V-FIT, Figs 1, 2), initially described by Warner (2017), and further discussed below.

TAXONOMY

Genus *Baeocera* Erichson, 1845

Remarks: Thirty-nine species of *Baeocera* are distributed in North America (Newton *et al*., 2001), one of them (*B. discolor* Casey, 1900) remains doubtful. Among these species, the following 12 have been described or reported from Arizona (Löbl & Stephan, 1993): *B. cerbera* (Cornell, 1967), *B. congener* Casey, 1893, *B. elongata* Löbl & Stephan, 1993, *B. eurydice* (Cornell, 1967), *B. flagellata* (Löbl, 1976), *B. hesperia* Löbl & Stephan, 1993, *B. humeralis* Fall, 1910, *B. impunctata* Löbl & Stephan, 1993, *B. lenczyi* Löbl & Stephan, 1993, *B. solida* Löbl & Stephan, 1993, *B. sticta* Löbl & Stephan, 1993 and *B. valida* (Löbl, 1976). The newly examined collection comprises ten species, with *B. hamata* Löbl & Stephan, 1993 and *B. nana* Casey, 1893 recorded here for the first time from Arizona, and three species described below as new to science.

Baeocera cerbera (Cornell, 1967)

Material examined: MHNG, WBWC; 4 females; Arizona, Cochise Co. Huachuca Mts.; 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W, July 4-24, 2019.

Remarks: This species is known from Arizona and Texas and had been previously collected in Cochise County by sifting leaf litter in oak forests.

Baeocera elongata Löbl & Stephan, 1993

Material examined: MHNG, WBWC; 26 specimens; Arizona, Maricopa Co. along Sycamore Creek at Sunflower; 33.8651°N, 111.4657°W; July 16 - Aug. 4, 2019. – MHNG, WBWC; 5 specimens; Arizona, Santa Cruz Co. Old Ruby Rd., 0.9 km W of I-19; 31.4225°N, 110.9736°W, Aug. 6 - Sep. 18, 2019. – MHNG, WBWC; 11 specimens; Arizona, Santa Cruz Co. Palo Prado Rd., east side Santa Cruz R., 31.531°N, 111.016°W; July 11-16, 2018. – MHNG, WBWC; 52 specimens; Arizona, Santa Cruz Co. Duquesne Rd., 2.3 rd. mi E jct. Hwy 82, Santa Cruz R., 31.3757°N, 110.8406°W, Aug. 3-14. 2018. – MHNG, WBWC; 12 specimens; Arizona, Pima Co., 0.3 km W Hwy 83 on Gardner Cyn. Rd., 31.7367°N, 110.6663°W, 4722 ft., July 5 - Aug. 6, 2019. – MHNG, WBWC; 36 specimens; Arizona, Gila Co. Tonto Ck., 0.2 mi. S of Gisela, 34.0862°N, 111.2874°W, 2845 ft., July 6 - 21, 2018.

Remarks: As the previous species, *B. elongata* is known from Arizona and Texas only. It was based on a few specimens only, and new county records are Maricopa and Gila. It was previously collected by sifting leaf litter in oak forests and in sycamore litter.

Baeocera hamata Löbl & Stephan, 1993

Material examined: MHNG, WBWC; 4 specimens; Arizona, Cochise Co. Huachuca Mtns., Carr Cyn. below Carr house, 31.4447°N, 110.2864°W, Aug. 15-31, 2018. – MHNG, WBWC; 14 specimens; Arizona, Cochise Co. Huachuca Mts., 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W, July 4 - 24, 2019. – MHNG; 1 specimen; Arizona, Pima Co., 0.3 km W Hwy 83 on Gardner Cyn. Rd., 31.7367°N, 110.6663°W, 4722 ft., July 5 - Aug. 6, 2019.

Remarks: This species was based on a single specimen from Texas without specified collecting method. While its aedeagus is distinctive, the elytral punctation considered by Löbl & Stephan (1993) as diagnostic, is too variable and dissection of aedeagus is required to confirm its species identity. The examined specimens are 1.52-1.68 mm long, somewhat smaller than the holotype.

Baeocera hesperia Löbl & Stephan, 1993

Material examined: MHNG, WBWC; 10 specimens; Arizona, Cochise Co. Huachuca Mts., 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W, July 4-24, 2019.

Fig. 1. V-flight intercept trap, with metal frame.

Fig. 2. Travel version of V-flight intercept trap.

Remarks: The species was based on a few specimens from Arizona and Colorado and considered rare by Löbl & Stephan (1993). Prior specimens recorded by Löbl & Stephan (1993) were collected by coleopterists who routinely sifted litter.

Baeocera humeralis Fall, 1910

Material examined: MHNG, WBWC; 9 specimens; Arizona, Cochise Co. Huachuca Mts.; 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W, Aug. 31- Sept. 28, 2018.

Remarks: This species is widely distributed throughout North America and has been collected by sifting litter and by FIT (Löbl & Stephan 1993). Previous studies by Cornell (1967) and Löbl & Stephan (1993) do not provide county records.

Baeocera impunctata Löbl & Stephan, 1993

Material examined: MHNG, WBWC; 4 specimens; Arizona, Maricopa Co. along Sycamore Creek at Sunflower, 33.8651°N, 111.4657°W, Jul. 16-Aug. 4, 2019. – MHNG, WBWC; 16 specimens; Arizona, Gila Co. along Tonto Ck., 0.2 mi. S of Gisela, 34.0862°N, 111.2874°W, 2845 ft., July 6-21, 2018. – MHNG, WBWC; 13 specimens; Arizona, Pima Co., 0.3 km W Hwy 83 on Gardner Cyn. Rd., 31.7367°N, 110.6663°W, 4722 ft., July 5- Aug. 6, 2019. – MHNG, WBWC; 7 specimens; Arizona, Santa Cruz Co. Duquesne Rd., 2.3 rd. Mi E jct. Hwy 82, Santa Cruz R., 31.3757°N, 110.8406°W, Aug. 3-14, 2018. – MHNG, WBWC; 6 specimens; Arizona, Santa Cruz Co. Palo Prado Rd., east side Santa Cruz R., 31.531°N, 111.016°W, July 11-16, 2018. – WBWC; 2 specimens; Arizona, Santa Cruz Co. 3.7 rd. mi. SE of Patagonia on Harshaw RD, 31.5163°N, 110.7043°W, July 24 - Aug. 6, 2019. – MHNG, WBWC; 26 specimens; Arizona, Cochise Co. Huachuca Mts., 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W, July 4-24, 2019. – WBWC; 3 specimens; Arizona, Cochise Co. Huachuca Mts., 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W, Aug. 31- Sept. 28, 2018. – WBWC; 1 specimen; Arizona, Cochise Co. Huachuca Mts., Carr Cyn. below Carr house, 31.4447°N, 110.2864°W, Aug. 15-31, 2018.

Remarks: The species was based on few specimens from Arizona and New Mexico and remains unknown from other states. It was collected previously in Pima County by sifting moist leaf litter (Löbl & Stephan, 1993) and new county records are: Cochise, Gila, Maricopa, and Santa Cruz.

Baeocera nana Casey, 1893

Material examined: MHNG, WBWC; 4 specimens; Arizona, Cochise Co. Huachuca Mts.; 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W, July 4-24, 2019.

Remarks: This species is widely distributed throughout North America and has been collected in many habitats by sifting as well as FIT and recorded from slime moulds (Cornell, 1967; Lawrence & Newton, 1980; Löbl & Stephan, 1993).

Baeocera arizonensis Löbl, sp. nov.

Figs 3-5

Material examined:
Holotype: MHNG (# MHNG-ENTO-86101); male; USA: AZ: Cochise Co. Huachuca Mts.; 0.8 rd. mi. SW Reef; 31.4238° - 110.2991°; July 4-24.2019; V-flight intercept trap; W.B. Warner.
Paratypes: MHNG, WBWC; 2 males, 1 female; with the same data as the holotype. – WBWC; 1 male; with the same data but Aug. 31-Sept. 28, 2018.

Etymology: The species epithet refers to Arizona.

Diagnosis: The species is defined by the following characters in combination: body length about 1.20-1.30 mm, elytra lighter than most of pronotum, lateral margins of pronotum and elytra continuously arcuate, elytron with basal stria broadly separated from lateral stria, lateral parts of metaventrite finely punctate, ventrite I with basal striae, aedeagus symmetrical, with tapering apical process, parameres sinuate and narrowed posterior basal third, internal sac with complex sclerites, as in Figs 3, 4.

Description: Length 1.23-1.28 mm, width 0.75-0.85 mm. Head and most of pronotum dark brown, pronotum near lateral margins, hypomeres, elytra and appendages ochraceous, mesoventrite, mesanepisterna, metaventrite, metanepisterna and abdomen dark brown to blackish. Antennomere II twice as long as antennomere III. Length/width ratios of antennomeres as: III 15/7: IV 18/6: V 20/6: V1 17/7: VII 20/9: VIII 17/10: IX 30/15: X 27/16: XI 43/18. Pronotum and elytra continuously arcuate. Pronotal punctation hardly visible at 50 times magnification, microsculpture indistinct. Marginal carinae of pronotum not visible in dorsal view. Point of scutellum exposed. Elytron weakly narrowed apically, with lateral margin rounded near base and apex, oblique at middle, adsutural area flat and broad, sutural stria punctate, curved along base to form basal stria; basal stria extended slightly outward basal half of elytral width and broadly separated from lateral stria, gradually approximate to basal margin; lateral stria punctate. Elytral disc not microsculptured, with punctation less fine than that on pronotum. Hypomeron impunctate. Mesepimeron about twice to three times

as long as wide and about 1.5 times as long as distance to coxa. Median part of metaventrite flattened, with impunctate narrow central area delimited laterally and apically by dense patch of fine punctures. Remaining punctation on metaventrite hardly visible at 100 times magnification. Submesocoxal lines convex, with row of small, not elongate pits, not extended laterally. Submesocoxal areas 0.05-0.06 mm long, about as half to two-thirds of shortest distance to metacoxae. Exposed part of metanepisternum flat, about 0.08-0.09 mm wide, with suture finely punctate, straight or somewhat curved. Tibiae straight. Abdominal punctation finer that elytral punctation, microsculpture punctulate, hardly visible. Ventrite I with basolateral striae 0.08-0.12 mm long, row of fine basal pits interrupted at middle. Aedeagus (Figs 3-5) 0.47-0.52 mm long, weakly sclerotized.

Distribution: USA, Arizona.

Type locality: Arizona, Cochise Co. Huachuca Mts., 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W.

Remarks: The species is a member of the *B. picea* group as defined in Löbl & Stephan (1993). Its aedeagal characters suggest relationship with *B. borealis* Löbl & Stephan, 1993 by having the same peculiar shape of the parameres. The shape of the median lobe is also similar though the apical process is in *B. arizonensis* narrower in lateral view. The new species may be easily distinguished from *B. borealis* by the bicolorous body, the long laterobasal striae of the ventrite I, and the shape of the sclerotized pieces of the internal sac. It falls in the key to the North American *Baeocera* (Löbl & Stephan, 1993) under the couplet 5, to *B. elongata* Löbl & Stephan, 1993. *B. elongata* is significantly larger and has the submesocoxal lines nearly parallel with the margin of coxal cavities, and deep striae at the base of the ventrite I.

***Baeocera obscura* Löbl, sp. nov.**

Figs 6-8

Material examined:

Holotype: MHNG (# MHNG-ENTO-86102); male; USA: AZ: Cochise Co. Huachuca Mts.; 0.8 rd. mi. SW Reef; 31.4238° - 110.2991°; Aug. 31 - Sept. 28, 2018; V-flight intercept trap; W.B. Warner.

Paratypes: WBWC, MHNG; 4 females, with the same data as the holotype. – MHNG; 1 female; with the same data but July 4-24.2019.

Etymology: The species epithet is a Latin adjective meaning dull.

Diagnosis: The species is defined by the following characters in combination: body length about 1.0-1.20 mm, body light brown, lateral margins of pronotum and elytra separately arcuate, elytron with basal stria broadly separated from lateral stria, lateral parts of metaventrite with hardly visible punctation, ventrite I without basal striae, aedeagus as Figs 6-8, weakly sclerotized, symmetrical and narrow, parameres nearly throughout evenly narrow and weakly curved, internal sac lacking sclerites, with very thin, weakly sclerotized flagellum.

Description: Length 1.06-1.20 mm, width 0.73-0.84 mm. Body light brown, pronotum and elytra sometimes somewhat lighter than venter of thorax and abdomen. Femora, tibiae and antennomeres I and II about as light as venter of thorax, tarsi and antennomeres III to XI lighter, yellowish. Antennomere II slightly longer than antennomere III. Length/width ratios of antennomeres as: III 16/5: IV 16/5: V 23/5: VI 18/7: VII 24/11: VIII 23/10: IX 30/12: X 28/14: XI 28/15. Pronotum and elytra separately arcuate, both with punctation fine, hardly visible at 50 times magnification, pronotal microsculpture indistinct. Marginal carinae of pronotum not visible in dorsal view. Point of scutellum exposed. Elytron weakly narrowed apically, with lateral margin weakly rounded, adsutural area flat and broad, sutural stria impunctate, curved along base to form basal stria extended slightly outward basal half of elytral width and broadly separated from lateral stria, not approximate to basal margin; lateral stria appearing impunctate. Elytral disc with distinct punctulate microsculpture. Hypomeron impunctate. Mesepimeron about three times as long as wide and six times as long as distance to coxa. Median part of metaventrite flattened, with distinct U-shaped row of fine punctures. Remaining punctation on metaventrite hardly visible at 100 times magnification. Submesocoxal lines convex, with row of small, not elongate pits, not extended laterally. Submesocoxal areas 0.03 mm long, about as third to fourth of shortest distance to metacoxae. Exposed part of metanepisternum flat, 0.06 to 0.08 mm wide, with suture deep, impunctate, straight or somewhat curved. Protibiae and mesotibiae straight, metatibiae hardly curved. Abdominal punctation as fine as that on elytra, microsculpture punctulate, distinct. Ventrite I without basal striae, basal row of fine pits interrupted at middle. Aedeagus (Figs 6-8) 0.29 mm long, weakly sclerotized.

Distribution: USA, Arizona.

Type locality: Arizona, Cochise Co. Huachuca Mts., 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W.

Remarks: The sole available male has the tip of the median lobe broken off and the basal bulb deformed, though the distinguishing characteristics are retained for naming this species. The shape of the median lobe and parameres of this species are similar with those in members of the *B. picea* group as defined by Löbl & Stephan (1993) while the presence of a flagellum and the internal sac lacking proximal sclerotized structures

suggest relationship with members of the *B. apicalis* group. Notable is the very thin flagellum much narrower than that in its North American congeners. The new species falls in the key to the North American *Baeocera* under the couplet 12, to *B. similaris* Löbl & Stephan, 1993. It differs drastically from *B. similaris* by the elytral and abdominal microsculpture, and by the ventrite I margined by round, not elongate, pits.

***Baeocera vintercepta* Löbl, sp. nov.**

Figs 9, 10

Material examined:

Holotype: MHNG (# MHNG-ENTO-86103); male; USA: AZ: Gila Co. along Tonto Ck., 0.2 mi. S of Gisela; elev. 2845 ft.; 34.0862°, -111.2874°; July 6-21, 2018, V-flight intercept trap; W.B. Warner.

Paratypes: MHNG; 3 males, 2 females; USA: AZ: Santa Cruz Co. Duquesne Rd., 2.3 rd. mi E jct. Hwy 82; Santa Cruz R.; 31.3757°, -110.8406° Aug. 3-14. 2018; V-flight intercept trap; W.B. Warner. – MHNG; 1 male; USA: AZ: Santa Cruz Co. Palo Prado Rd., east side Santa Cruz R.; 31.531°, 111.016°; July 11-16, 2018; V-flight intercept trap; W.B. Warner (MHNG); – WBWC; 1 male; USA: AZ: Maricopa Co. along Sycamore Creek at Sunflower; 33.8651°, -111.4657°; Jul.16-Aug.4.2019; V-flight intercept trap; W.B. Warner.

Etymology: The species epithet is a Latin adjective referring to the mode of collection, the v-flight intercept traps providing remarkable results.

Diagnosis: The species is defined by the following characters in combination: body length about 1.10-1.25 mm, body dark brown, lateral margins of pronotum and elytra separately arcuate, elytron with basal stria broadly separated from lateral stria, lateral parts of metaventrite with hardly visible punctation, ventrite I with basal striae, aedeagus as Figs 9, 10, symmetrical and narrow, median lobe tapering in lateral view, with obtuse tip in dorsal view, parameres abruptly narrowed near apices, internal sac with complex sclerites.

Description: Length 1.10-1.23 mm, width 0.77-0.80 mm. Body dark brown. Legs lighter, reddish to yellowish, tibiae and tarsi lighter than femora. Antennomeres I to VI about as light as tarsi. Antennomere II about twice as long as antennomere III. Length/width ratios of antennomeres as: III 12/7: IV 17/6: V 18/6: VI 18/6: VII 24/9: VIII 19/10: IX 26/13: X 28/14: XI 40/16. Pronotum and elytra separately arcuate, pronotum with punctation fine, hardly visible at 50 times magnification, pronotal microsculpture indistinct, elytra not microsculptured. Marginal carinae of pronotum not visible in dorsal view. Point of scutellum exposed. Elytron weakly narrowed apically, with lateral margin rounded near base and apex, oblique in middle third, adsutural area flat and narrow, sutural stria impunctate, curved along base to form basal stria extended slightly outward basal half of elytral width and broadly separated from lateral stria, somewhat approximate to basal margin; lateral stria appearing impunctate. Discal punctation less fine that that on pronotum, distinct at 50 times magnification. Hypomeron impunctate. Mesepimeron hardly three times as long as wide and about 1.5 times as long as distance to coxa. Median part of metaventrite flattened, with distinct, dense punctation laterally centre. Remaining punctation on metaventrite hardly visible at 100 times magnification. Submesocoxal lines convex, with row of small, not elongate pits, not extended laterally. Submesocoxal areas 0.04-0.05 mm long, nearly as half of shortest distance to metacoxae. Exposed part of metanepisternum flat, 0.05-0.07 mm wide, suture of metanepisternum deep, impunctate, straight. Tibiae straight. Abdominal punctation as fine as that on elytra, microsculpture punctulate, distinct. Ventrite I with basal row of fine pits interrupted at middle and extended by fine, 0.08-0.12 mm long striae. Aedeagus (Figs 3, 4) 0.39-0.42 mm long, weakly sclerotized.

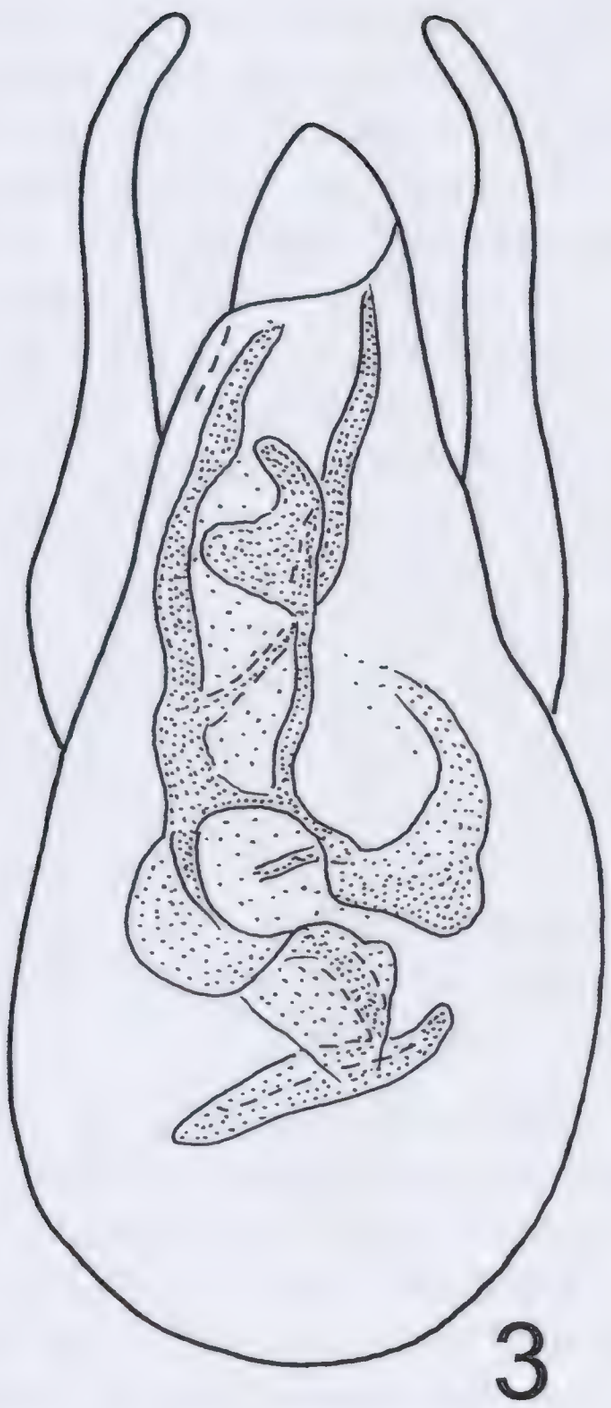
Distribution: USA, Arizona.

Type locality: Arizona, Gila Co. along Tonto Ck., 0.2 mi. S of Gisela, 34.0862°N, 111.2874°W, 2845 ft.

Remarks: This new species is clearly a member of the *B. picea* group (see Löbl & Stephan, 1993). The median lobe and parameres are similar with those in *B. scylla* (Cornell, 1967), while the shape of the sclerites of the internal sac are distinctive, and the presence of a proximal subtriangular plate is diagnostic for this new species. *Baeocera vintercepta* is readily distinguished from *B. scylla* by the longitudinal striae at the base of the ventrite I. It may be separated also by the comparatively shorter antennomere XI which is in *B. scylla* nearly twice as long as the antennomere X, the submesocoxal lines being not parabolic and having the submesocoxal areas much shorter. The new species falls in the key to the North American *Baeocera* (Löbl & Stephan, 1993) under the couplet 5, to *B. elongata* Löbl & Stephan, 1993, as *B. arizonensis*. These two species possess very distinctive aedeagi, in addition *B. vintercepta* may be easily distinguished by the uniformly dark body and the antennomeres XI larger, more than twice as long as wide.

Genus *Scaphisoma* Leach, 1815

Remarks: This genus comprises less species in North America that *Baeocera*, while the opposite is in the Old World. To date, 23 species of *Scaphisoma* have been reported from the USA (Newton *et al.,* 2001), including *S. americanum* (Löbl, 1987) originally placed in the subsequently synonymized *Caryoscapha* (see Leschen



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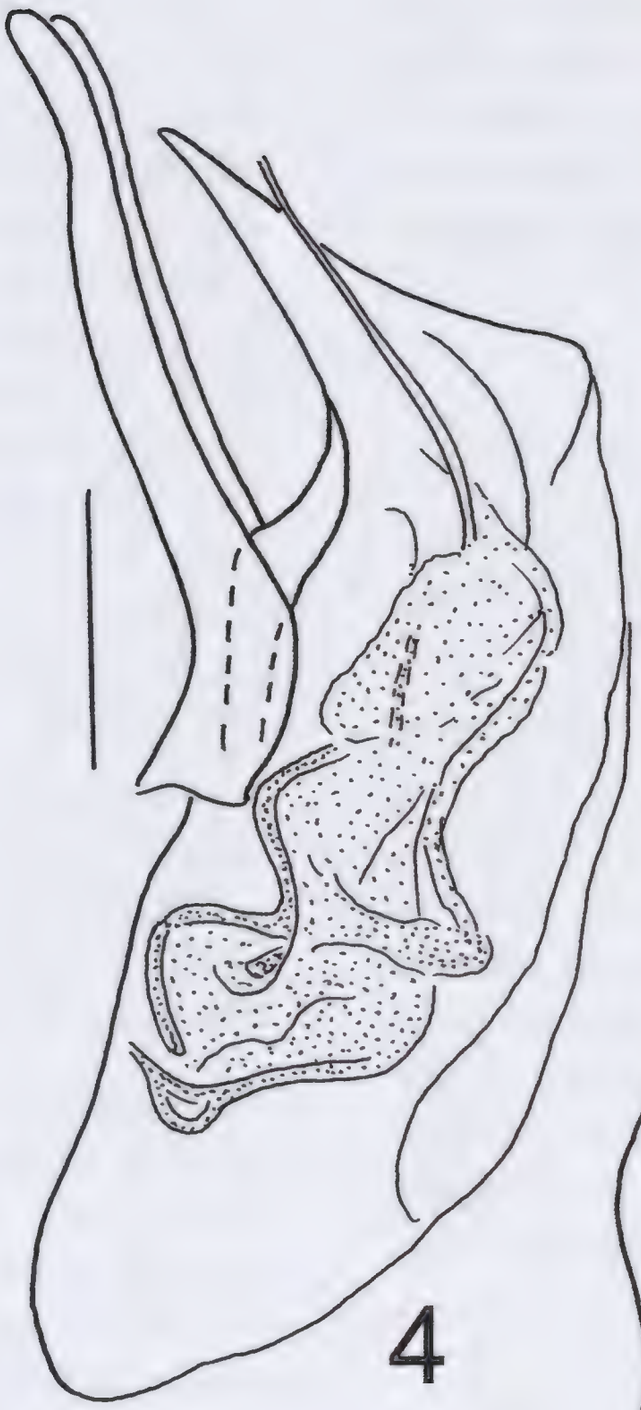

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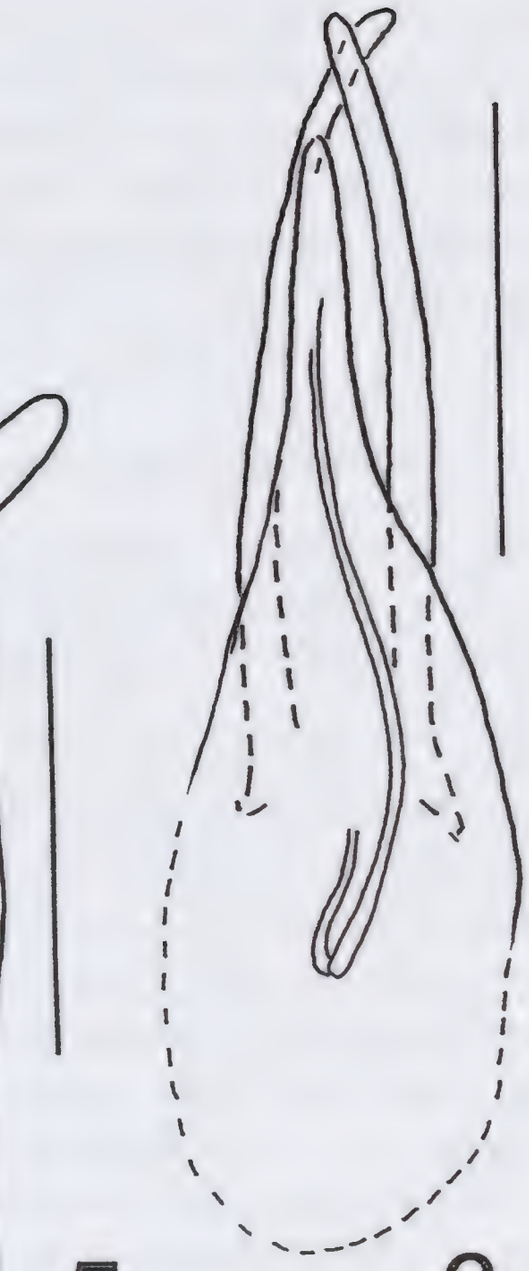

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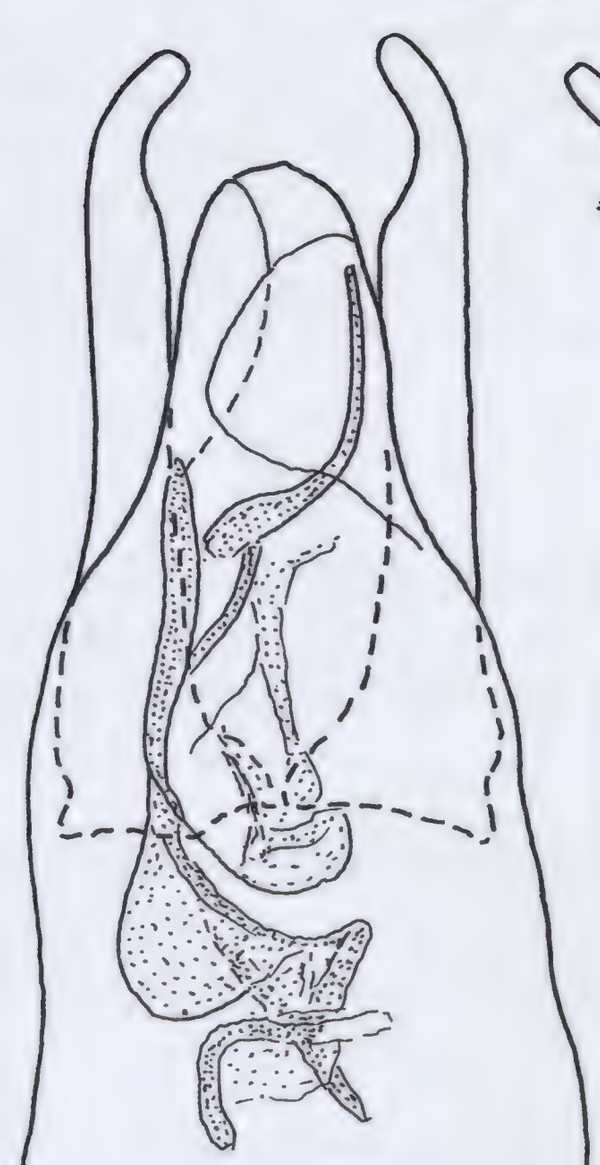

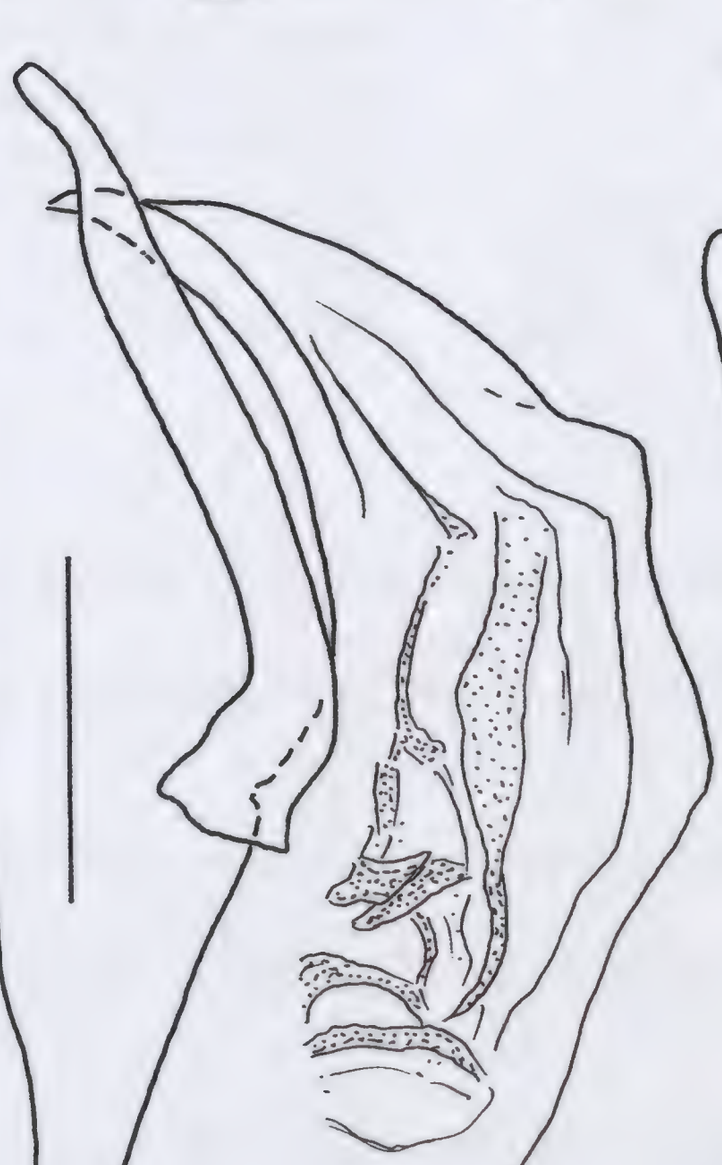

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Figs 3-10. Aedeagi in *Baeocera*. (3 - 4) *B. arizonensis* Löbl, sp. nov., in dorsal and lateral views, scale = 0.1 mm. (5) Ditto, paramere in ventral view, scale = 0.1 mm. (6-7) *B. obscura* Löbl, sp. nov., in dorsal and lateral views, scale = 0.1 mm (basal bulb deformed, tip of apical process broken). (8.) Ditto, paramere in ventral view, scale = 0.05 mm. (9-10) *B. vintercepta Löbl*, sp. nov., in dorsal and lateral views, scale = 0.1 mm.

& Löbl, 2005). The following four species have been listed from Arizona in Löbl (2018): *S. commune* Löbl, 1997 based on probably a mislabelled specimen of *S. convexum* Say, 1825 (see Casey, 1893), *S. desertorum* Casey, 1893, *S. pusillum* LeConte, 1860, and *S. rufulum* LeConte, 1860.

Scaphisoma convexum Say, 1825

Material examined: WBWC; 1 female; Arizona, Cochise Co. Huachuca Mts., 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W, July 4-24, 2019.

Remarks: The species is in external characters similar with *S. commune* Löbl, 1997 [a replacement name for the homonymous *S. castaneum* (Motschulsky, 1845)]. The puncture pattern of the metaventrite and ventrite I enables reliable identification. In addition, the aedeagi of these species differ drastically: *S. commune* possesses a long, thin flagellum extruded in repose while *S. convexum* has a robust rod as illustrated in Leschen *et al.* (1990). *Scaphisoma convexum* can be collected in numbers from basidiomycete fungi (Newton, 1984; Leschen *et al.*, 1990).

Scaphisoma desertorum Casey, 1893

Figs 13-14

Material examined: MHNG, WBWC; 16 specimens; Arizona, Maricopa Co. along Sycamore Creek at Sunflower; 33.8651°N, 111.4657°W, July 16 - Aug. 4, 2019. – WBWC; 2 specimens; Arizona, Santa Cruz Co. 3.7 rd. mi. SE of Patagonia on Harshaw RD; 31.5163°N, 110.7043°W; July 24 - Aug. 6, 2019. – MHNG, WBWC; 32 specimens; Arizona, Santa Cruz Co. Palo Prado Rd., east side Santa Cruz R.; 31.531°N, 111.016°W; July 11-16, 2018. – WBWC; 5 specimens; Arizona, Gila Co. along Tonto Ck., 0.2 mi. S of Gisela; 2845 ft., 34.0862°N, 111.2874°W, July 6-21, 2018. – MHNG, WBWC; 25 specimens; Arizona, Santa Cruz Co. Duquesne Rd., 2.3 rd. Mi E jct. Hwy 82; Santa Cruz R.; 31.3757°N, 110.8406°W, Aug. 3-14, 2018. – MHNG, WBWC; 13 specimens; Arizona, Cochise Co. Huachuca Mts., 0.8 rd. mi. SW Reef; 31.4238°N, 110.2991°W, Aug. 31 - Sept. 28, 2018. – WBWC; 7 specimens; Arizona, Cochise Co. Huachuca Mts.; 0.8 rd. mi. SW Reef; 31.4238°N, 110.2991°W, July 4-24. 2019. – WBWC; 2 specimens; Arizona, Pima Co.; 0.3 km W Hwy 83 on Gardner Cyn. Rd., 4722 ft., 31.7367°N, 110.6663°W, July 5 - Aug. 6, 2019.

Remarks: The species was based on an unknown number of specimens from Arizona and Texas (Casey, 1893: 530). The senior author has examined a male syntype labelled "Williams Ariz" / "TYPE USNM 48161" / "desertorum" (handwritten). As its aedeagal characters have not yet been published, respective illustrations are given here (Figs 13, 14). An examined male syntype of *Scaphisoma dakotanum* Fall, 1910, originally spelled dakotana, labelled "Wickham, Bismarck, N. Dak." / "dakotana TYPE" / "M.C.Z. Type 24119" / "H.C.Fall collection" / "Scaphisoma dakotana Fall" is found conspecific with *S. desertorum*. It is here

Key to the Arizona species of *Scaphisoma*

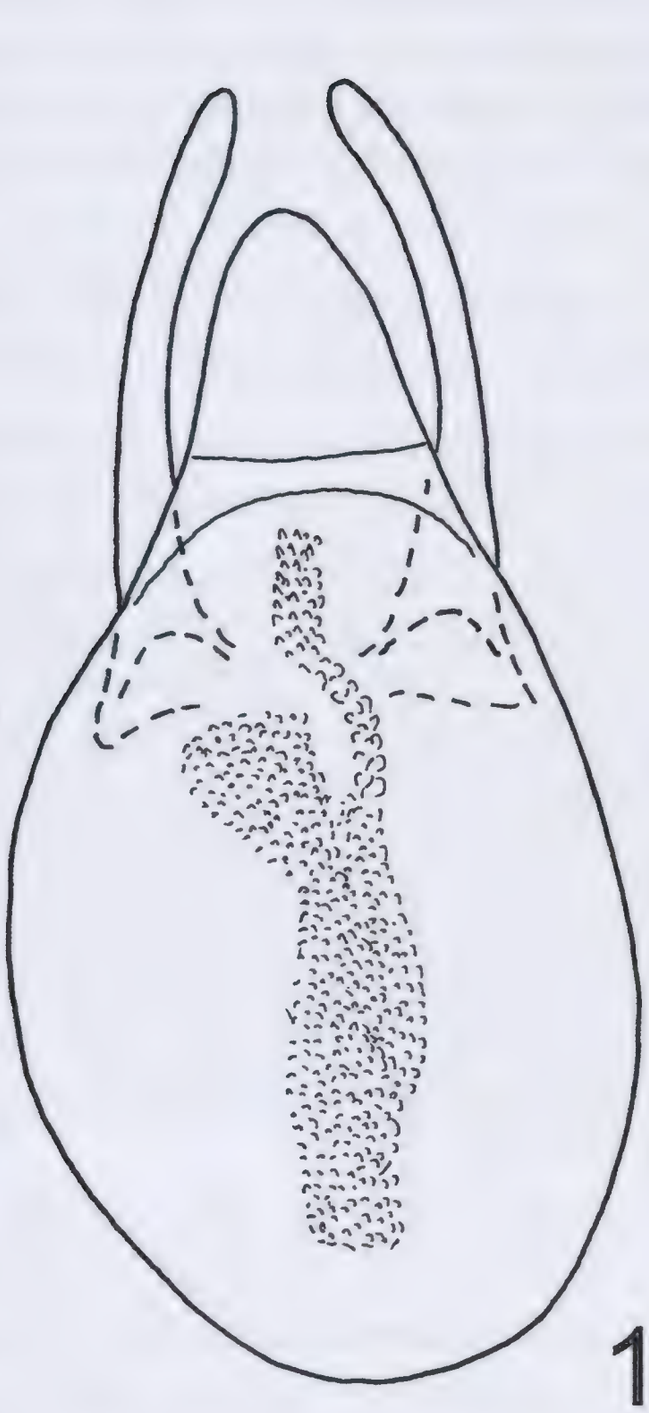
1 Body length 1.0-1.20 mm. Submetacoxal area large, extending to or nearly to mid-length of ventrite I, not margined by punctures ..... *S. pusillum* LeConte
- Body length 1.50 to 2.80 mm. Submetacoxal area small, much shorter than mid-length of ventrite I, margined by punctures 2

2 Mesepimeron completely or to partly fused with mesanepisternum. Antennomeres IV and V similar. Metaventrite and abdomen very finely punctate ..... *S. rufulum* LeConte
- Mesepimeron distinct. Antennomere V much larger than antennomere IV. Metaventrite and/or abdomen entirely or in part distinctly punctate 3

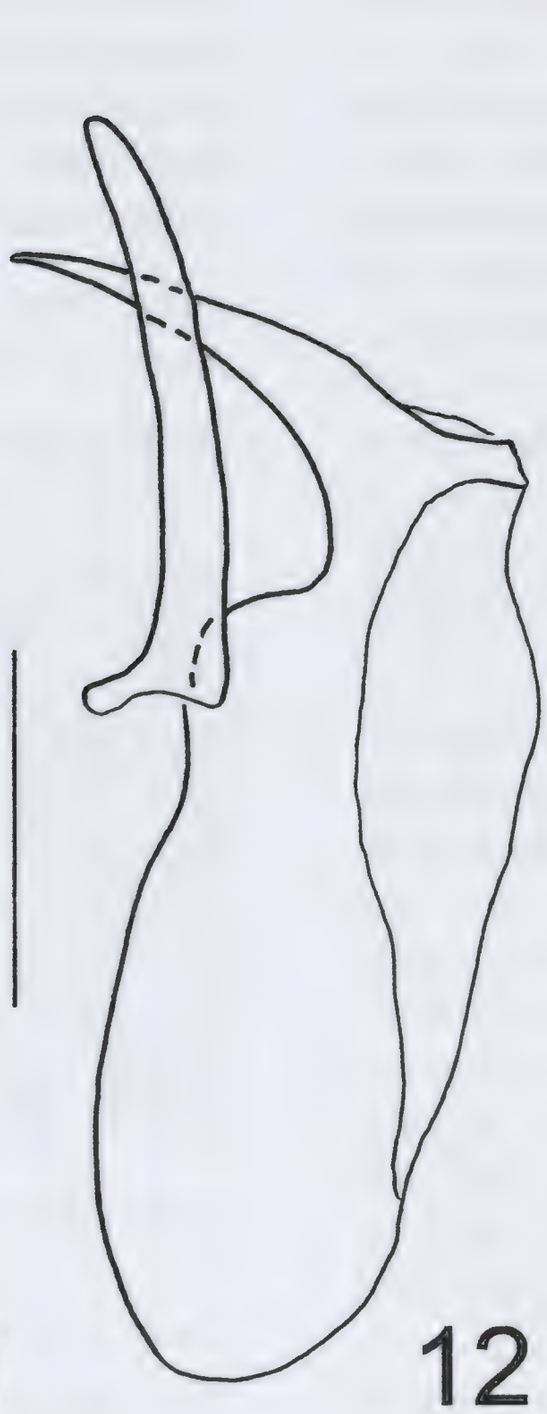
3 Metaventrite posterior submesocoxal lines and on centre much more coarsely punctate than on lateral area. Internal sac of aedeagus with robust rod ..... *S. convexum* Say
- Metaventrite with punctation similar on centre, posterior submesocoxal lines and on lateral areas. Internal sac of aedeagus without rod 4

4 Internal sac of aedeagus with long, thin flagellum extruded in repos ..... [*S. commune* Löbl]
- Internal sac of aedeagus lacking flagellum 5

5 Body dark reddish-brown to blackish. Antennomere VI longer than antennomeres IV and V combined. Aedeagus with basal capsule shorter than parameres ..... *S. desertorum* Casey
- Body light reddish-brown. Antennomere VI shorter than antennomeres IV and V combined. Aedeagus with basal capsule longer than parameres ..... *S. declivum* sp. nov.



11



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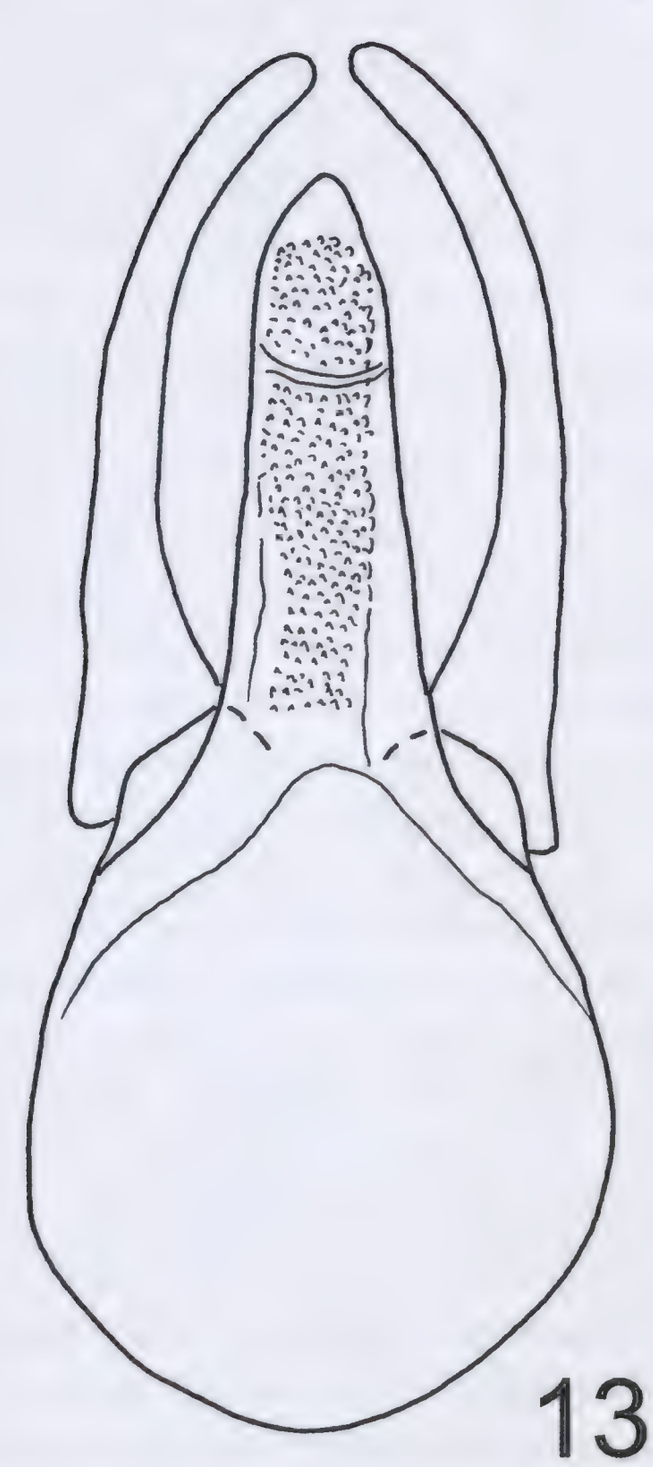

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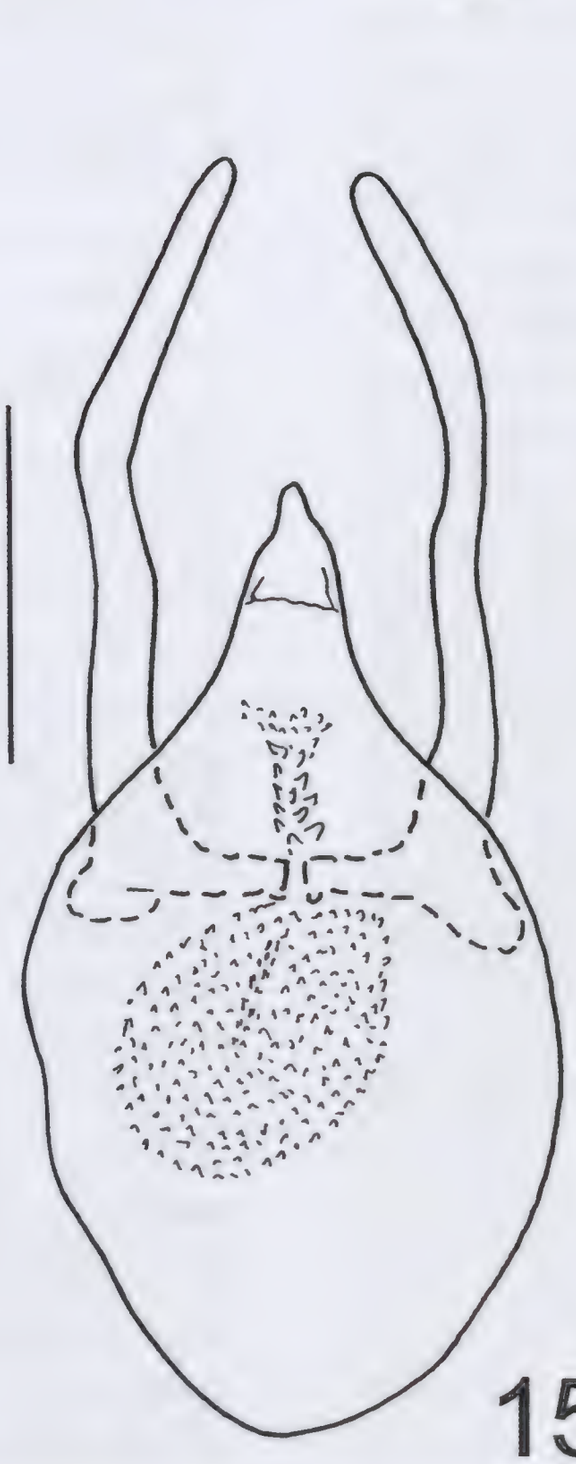

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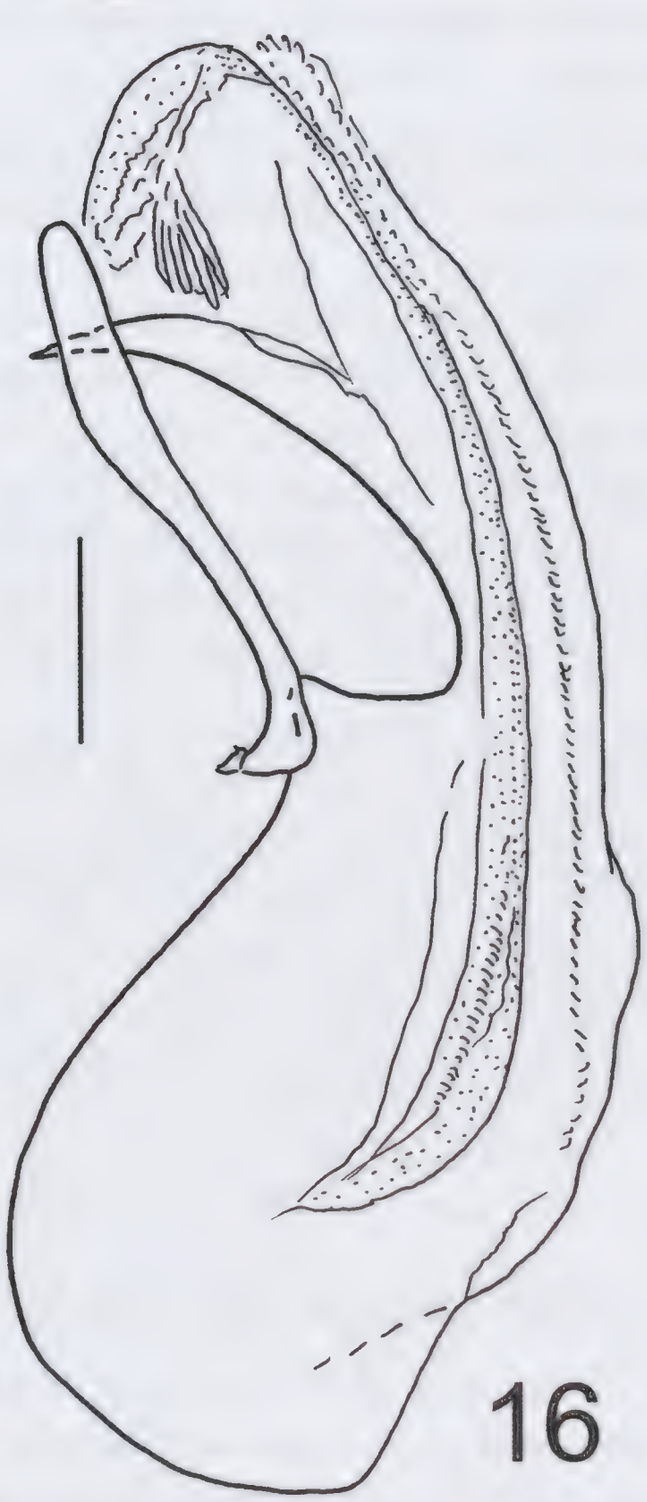

16

Figs 11-16. Aedeagi in *Scaphisoma*. (11-12) *S. declivum* Löbl, sp. nov., in dorsal and lateral views, scale = 0.1 mm. (13-14) *S. desertorum* Casey, in dorsal and lateral views, scale = 0.2 mm. (15) *S. rufulum* LeConte, in dorsal view, scale = 0.2 mm. (16) *S. rubens* Casey, in lateral view, internal sac extruded, scale = 0.1 mm.

designated as lectotype, and bears respective label, dated 1987.
Hence, *Scaphisoma dakotanum* Fall, 1910, **syn. nov.** = *S. desertorum* Casey, 1893.
This species is reported from Arizona, North Dakota and Texas, the vouchers from Texas were not examined.

Scaphisoma pusillum LeConte, 1860

Material examined: MHNG; 1 female; Arizona, Cochise Co. Huachuca Mts.; 0.8 rd. mi. SW Reef; 31.4238°N, 110.2991°W; July 4-24, 2019.

Remarks: The species is widely distributed throughout the United States but does not occur in Canada. It has been collected by sifting hay (Leschen *et al*., 1990).

Scaphisoma rufulum LeConte, 1860

Fig. 15

Material examined: MHNG, WBWC; 1 male, 1 female; Arizona, Santa Cruz Co. Duquesne Rd., 2.3 rd. Mi E jct. Hwy 82; Santa Cruz R., 31.3757°N, 110.8406°W, Aug. 3-14, 2018. – MHNG, WBWC; 1 male, 1 female; Arizona, Santa Cruz Co. Palo Prado Rd., east side Santa Cruz R.; 31.531°N, 111.016°W, July 11-16, 2018.

Remarks: This species was based on a single specimen (LeConte, 1860: 323). It is a male examined by the senior author in 1987, bearing the following labels: small, round golden-colour label, "TYPE 6639" (red) / "S. rufulum Lec. Cal." (handwritten) and my determination label dated 1987. The aedeagus is illustrated for the first time in the present paper (Fig. 15). It is similar with that of *S. impunctatum* Reitter, 1879 (see Leschen *et al.,* 1990), suggesting close relationships. It differs from that of *S. impunctatum* by the apical process of the median lobe less inclined, and the parameres more sinuate in dorsal view and narrowed apically in lateral view. *Scaphisoma rufulum* may be distinguished from *S. impunctatum* also by its lighter body and completely or to large part fused mesepimera, as in those of *S. carolinae* Casey, 1893.
This species is reported from California, Arizona and North Carolina (Löbl, 2018).

Scaphisoma declivum Löbl, sp. nov.

Figs 11-12

Material examined:
Holotype: MHNG (# MHNG-ENTO-86104); male; USA: AZ: Santa Cruz Co. Palo Prado Rd., east side Santa Cruz R.; 31.531°, 111.016°; July 11-16, 2018; V-flight intercept trap; W.B. Warner.
Paratypes: MHNG, WBWC; 2 males, 4 females with the same data as the holotype; – WBWC, MHNG, 8 males, 13 females, USA: AZ: Santa Cruz Co. Duquesne Rd., 2.3 rd. Mi E jct. Hwy. 82; Santa Cruz R.; 31.3757°, -110.8406° Aug. 3-14, 2018; V-flight intercept trap; W.B. Warner

Etymology: The species epithet is a Latin adjective meaning inclined.

Diagnosis: The species is defined by the following characters in combination: body length about 1.70-2.10 mm, body light reddish-brown, antennomere VI about 1.5 times as long as antennomere V and twice as long as antennomere IV, elytron with basal stria broadly separated from lateral stria, elytral disc with punctures well delimited, dense and fine, submesocoxal areas about as long as third of shortest intervals to metacoxae, abdominal microsculpture punctulate, aedeagus as Figs 11, 12, symmetrical and narrow, median lobe shorter than basal bulb, strongly inflexed and tapering, with narrow dorsal bridge, parameres narrowed at middle section, internal sac membranous.

Description: Length 1.70-2.05 mm, width 1.16-1.55 mm. Head, most of body and femora evenly light reddish-brown. Apex of abdomen, antennae, tibiae, and tarsi lighter. Antennomeres I to VI about as light as tarsi. Antennomere II about twice as long as antennomere III. Length/width ratios of antennomeres as: III 13/10: IV 23/8: V 34/10: VI 48/12: VII 52/16: VIII 42/13: IX 49/16: X 50/17: XI 65/16. Pronotum with lateral margins rounded, lateral margin carinae usually visible in dorsal view, discal punctation dense and fine, consisting of well delimited punctures. Tip of scutellum exposed. Elytra moderately narrowed apically, lateral margin rounded, lateral margin carina exposed in dorsal view, inner apical angle about in level with outer apical angle, sutural margin not raised, adsutural area flat, narrowed apically, with irregular, very fine puncture row; sutural striae curved at base and extended laterally to form basal striae reaching about mid-width of basal margin, discal punctation very fine near base, dense and fine on prevailing surface, punctures well-delimited, puncture intervals on apical half of disc about twice to as large as puncture diameters. Exposed tergites very finely punctate, with distinct punctulate microsculpture. Hypomeron smooth. Mesepimeron distinctly shorter than distance between its tip and mesocoxa. Metaventrite finely, very densely punctate, not microsculptured, flattened at middle. Submesocoxal lines convex, densely margined with punctures; submesocoxal area about 0.05-0.06 mm long, as third of shortest distance to metacoxa. Metanepiternum narrowed anteriad. Ventrite I with punctation similar as metaventrite, microsculpture punctulate, sometimes obsolete or hardly visible, submetaxocal lines convex, densely margined with punctures; submetacoxal area 0.06-0.08 mm long, about as fourth to third of shortest

distance to apical margin. Following ventrites with conspicuous punctulate microsculpture. Male ventrite VI with small mesal process about 0.03 mm long. Male protarsomeres I to III distinctly widened, with tenant setae. Aedeagus (Figs 11, 12) 0.68-0.75 mm long, strongly sclerotized.

Distribution: USA: Arizona.

Type locality: Arizona, Santa Cruz Co. Palo Prado Rd., east side Santa Cruz R., 31.531°N, 111.016°W.

Remarks: The aedeagus of *S. declivum* is rather similar with that of *S. carolinae* Casey, 1893 and *S. rubens* Casey, 1893, but the apical process of the median lobe is much wider and comparatively shorter, and the parameres are evenly arcuate in dorsal view. The species may be easily distinguished from *S. carolinae* by the larger and lighter body and the distinct mesepimera, and from *S. rubens* by the elytra with basal striae. The aedeagus of *S. rubens* (Fig. 16) is distinctive in lateral view and illustrated for the first time in the present paper.

Genus *Toxidium* LeConte, 1860

Remarks: Two widely distributed species are known from the USA (Newton *et al.*, 2001): *T. compressum* Zimmermann, 1869 and *T. gammaroides* LeConte, 1860. They may be distinguished by the punctation of the metaventrite, as given in Casey (1893).

Toxidium gammaroides LeConte, 1860

Material examined: MHNG, WBWC; 9 specimens; Arizona, Cochise Co., Huachuca Mts., 0.8 rd. mi. SW Reef, 31.4238°N, 110.2991°W; Aug. 31 - Sept. 28, 2018. – MHNG, WBWC; 5 specimens, same data but July 4-24, 2019.

Remarks: The species is widely distributed throughout the USA and has been reported also from Canada, Mexico and Guatemala. The state record is new.

THE V-FIT AND NOTES ON ARIZONA SCAPHISOMATINI

The trap design (Fig. 1) used to collect the specimens discussed in this paper is a new iteration of the V-FIT described by Warner (2017). Each trap used end supports bent from a single 3 m (10 ft) long piece of 1.25 cm (0.5 inch) steel EMT conduit (electrical metallic tubing), and two 1.5 m long horizontal supports made from half of a length of the same conduit; the corners were connected by EMT conduit elbows. A 1.5 m (5 ft) by 2.4 m (8 ft) sheet of 0.1524 mm (6 mil), sometimes 0.1016 mm (4 mil) "natural" (semi-transparent) polyethylene film was attached to the frame with large binder clips, and a 1.5 m (5 ft) length of 10 mm (3/8 inch) diameter mild steel rebar was attached to the centre of the film, parallel to the horizontal supports to keep the film tight, but allow for movement to reduce the trap profile in winds (generally, winds up to 50 km/hr do not damage the trap). Large rocks or sand bags were placed over each corner of the "U-shaped" end supports, and four aluminium "half sized steamer trays" (single-use food service trays, about 32 cm x 25 cm x 6 cm deep) served as catchments and were filled with 4-5 L of propylene glycol as a non-toxic preservative. The trays were placed and centred about 3-4 cm below the centreline of the polyethylene "V" film and were covered with steel "chicken-wire" mesh as protection from vertebrate disturbance. Typically, insects impinging on the film slide down the surface and are caught in the preservative. Hovering insects may repeatedly fly against the film and descent until finally falling into the liquid. Some taxa with direct flight ricochet off the oblique surface into the catchment.

The "V" film provides a rain shield over the catchment, and the reflective aluminium pans may be attractive to some insects. During preliminary trials of different materials, using a black polyethylene garbage bag placed over the horizontal supports, like "rain shields" used on standard vertical netting FITs (SVN-FIT), noticeably decreased catch, especially of diurnal Hymenoptera. Without such cover, sunlight penetrates through the film "V" and reflects off the shiny aluminium trays, and then off the outside of the film perhaps acting as a daytime "light trap."

Propylene glycol preserves specimens well and allows for traps to be left for several weeks in the field between checks and servicing. Also, the specimens are available for DNA work (Moreau *et al.*, 2013). Specimens were sieved out using 0.5 mm stainless steel mesh sieve, placed into labelled containers without any other preservative, and then stored in that condition for up to a year or more before sorting.

Though not used for specimens in this study, light-weight "travel" versions (Fig. 2) have been developed and used in Neotropics using cord wrapped around trees, film attached to the cord with paper clips, and locally cut saplings for the centre weight and "spreader bars" to provide distance across the top of the film "V." For this "travel version," soapy water was used, with insects removed daily into containers of preservative.

Quantitative testing of capture rates between V-FIT and SNV-FITs would be invaluable. Especially important would be the determination of what taxa are more effectively caught between each. In a 10 pseudo-replicate pair-wise comparison (two contiguous traps, position of intercept portion exchanged daily for 10 days) against the same profile size of a SNV-FIT, the V-FIT caught over 2.5 times the number of insects (WBW hitherto unpublished data). Although increases in catch were generally seen for all flying taxa in the V-FITs compared to SNV-

FITs, species that tend to land on, then fly away from standard FIT netting (e.g. Chrysomelidae) are caught 10-30 times more in V-FITs than in FITs. How this relates to capture rates for scaphisomatines is uncertain, but intense sampling of any beetle group would lead to new discoveries.

Prior to this study, 16 species of Scaphisomatini were known from Arizona. We have increased the number of *Baeocera* species to 17, with an additional three new species together with four previously considered endemic (*B. sticta, B. elongata, B. lenczyi,* and *B. solida;* see Löbl & Stephan, 1993), to seven possibly endemics. With respect to *Scaphisoma*, we have increased the number of species occurring in Arizona from four to five, one of which is possibly endemic to Arizona. Likewise, one of the two widespread species of *Toxidium* is newly recorded from Arizona.

No members of the Scaphidiinae tribes Cyparíini Achard, 1924, Scaphidiini Latreille, 1806, or Scaphiini Achard, 1924 were collected in V-FITs in Arizona. This is not surprising since none of these groups have been reported from Arizona, though we would expect members of Cyparíini (*Cyparium* Erichson) to eventually be captured because Neotropical species are readily collected in SNV-FITs (e.g., specimens from Mexico collected by S. B. Peck are in the MHNG and from elsewhere in the Americas are in the Snow Entomological Museum, Lawrence, Kansas). Furthermore, Fierros-López (2005) listed intercept traps as one of the methods used to collect Mexican and Central American Scaphidiini (*Scaphidium* Olivier), and the nearest state record to Arizona for this genus may be Colorado (Newton *et al.,* 2001).

Scaphisomatini are effectively collected by sifting leaf litter, hand collecting from fungi, and in FIT's, and to a lesser extent by light trapping. To fully appreciate the diversity of Arizona Scaphisomatini, we would recommend using all collecting methods, in several different habitats, from lush forested ravines to desert arroyos. We would expect by further leaf litter sampling to produce additional species, especially flightless *Baeocera* species. Further collecting may also confirm the state record of *Scaphisoma commune*, currently based on a probably mislabelled specimen.

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REFERENCES

Ashe J.S. 1984. Description of the larva and pupa of *Scaphisoma terminatum* Melsh. and the larva of *Scaphium castanipes* Kirby with notes on their natural history (Coleoptera: Scaphidiidae). *The Coleopterists Bulletin* 38: 361-373.

Blackwelder R.E. 1939. Fourth supplement 1933 to 1938 to The Leng Catalogue of Coleoptera of America, North of Mexico. John D, Sherman, Jr., Mount Vernon, N.Y., 146 pp.

Casey T.L. 1893. Coleopterological Notices, V. Scaphidiidae. *Annals of the New York Academy of Sciences* 7: 510-533.

Cornell J.F. 1967. A taxonomic study of *Eubaeocera* new genus (Coleoptera: Scaphidiidae) in North America north of Mexico. *The Coleopterists Bulletin* 21: 1-17.

Fall H.C. 1910. Miscellaneous notes and descriptions of North American Coleoptera. *Transactions of the American Entomological Society* 36: 89-197.

Ferro L.M., Gimmel M.L., Harms K.E., Carlton C.E. 2012. Comparison of three collection techniques for capture of Coleoptera, with an emphasis on saproxylic species, in Great Smoky Mountains National Park, USA. *Insecta Mundi* 261: 1-31.

Fierros-López H.E. 2005. Revisión del género *Scaphidium* Olivier, 1790 (Coleoptera, Staphylinidae) de México y Céntroamerica. *Dugesiana* 12: 1-152.

Hanley R.S. 1996. Immature stages of *Scaphisoma castaneum* Motschulsky (Coleoptera: Staphylinidae: Scaphidiinae), with observation on natural history, fungal hosts and development. *Proceedings of the Entomological Society of Washington* 98: 36-43.

Lawrence J.F., Newton A.F. Jr. 1980. Coleoptera associated with the fruiting bodies of slime moulds (Myxomycetes). *The Coleopterists Bulletin* 34: 129-143.

LeConte J.L. 1860. Synopsis of the Scaphidiidae of the United States. *Proceedings of the Academy of Natural Sciences of Philadelphia* (1860): 321-324.

Leng C.W. 1920. Catalogue of the Coleoptera of America, North of Mexico. *John D. Sherman, Jr., Mount Vernon, N.Y.*, X + 470 pp.

Leng C.W., Mutchler A.J. 1927. Supplement 1919 to 1924 (inclusive) to Catalogue of the Coleoptera of America, North of Mexico. *John D. Sherman, Jr., Mount Vernon, N.Y.*, 78 pp.

Leschen R.A.B. 1988. The natural history and immatures of *Scaphisoma impunctatum* (Coleoptera: Scaphidiidae). *Entomological News* 99: 225-231.

Leschen R.A.B. 1994. Retreat-building by larval Scaphidiinae (Staphylinidae). *Mola* 4: 3-5.

Leschen R.A.B., Löbl I. 2005. Phylogeny and classification of Scaphisomatini Staphylinidae: Scaphidiinae with notes on mycophagy, termitophily, and functional morphology. *Coleopterists Society Monographs* 3: 1-63.

Leschen R.A.B., Löbl I., Stephen K. 1990. Review of the Ozark Highland *Scaphisoma* (Coleoptera: Scaphidiidae). *The Coleopterists Bulletin* 44: 274-294.

Löbl I. 1976. New species of the genus *Sciatrophes* Blackburn from Arizona (Coleoptera: Scaphidiidae). *The Coleopterists Bulletin* 30: 207-211.

Löbl I. 1987. Contribution to the knowledge of the genus *Caryoscapha* Ganglbauer (Coleoptera: Scaphidiidae). *The Coleopterists Bulletin* 41: 385-391.

Löbl I. 2018. Coleoptera: Staphylinidae: Scaphidiinae. World Catalogue of Insects. Volume 16, *Brill, Leiden/Boston*, XVI & 418 pp.

Löbl I., Stephan K. 1993. A review of the species of *Baeocera* Erichson (Coleoptera, Staphylinidae, Scaphidiinae) of America north of Mexico. *Revue suisse de Zoologie* 100: 675-733.

Moreau C.S., Wray B.D., Czekanski-Moir J.E. & Rubin B.E. 2013. DNA preservation: a test of commonly used preservatives for insects. *Invertebrate systematics* 27: 81-86.

Newton A.F. Jr. 1984. Mycophagy in Staphylinoidea (Coleopetra) (pp. 302-353). *In:* Wheeler Q., Blackwell M. (eds). Fungus/insect relationships. Perspectives in ecology and evolution. *Columbia University Press, New York*, 514 pp.

Newton A.F. Jr. 1991. Scaphidiidae (Staphylinoidea) (pp. 337-339). *In:* Stehr F.W. (ed.). Immature Insects. Volume 2. *Kendall/Hunt Publishing Company, Dubuque*, XVI + 975 pp.

Newton A.F., Thayer M.K., Ashe J.S., Chandler D.S. 2001. 22. Superfamily Staphylinoidea Latreille, 1802 Staphyliniformia Lameere, 1900; Brachelytra auctorum. 22. Staphylinidae Latreille, 1802 (pp. 272-418). *In:* Arnett R.H., Thomas M.C. (eds). American beetles. Volume 1. Archostemata, Myxophaga, Adephaga, Polyphaga: Staphyliniformia. *CRC Press; Boca Raton, London, New York, Washington, D.C.*, XV + 443 pp.

Stephenson S.L., Wheeler Q.D., McHugh J.V., Fraissinet P.R. 1994. New North American associations of Coleoptera with Myxomycetes. *Journal of Natural History* 28: 921-936.

Warner W.B. 2017. Sliding Down the V: A low cost and efficient Flight Intercept Trap. *Scarabs* 83: 15-18.

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First record of Disk-footed bat *Eudiscopus denticulus* (Osgood, 1932) (Chiroptera: Vespertilionidae) from India with notes on its ecology and genetics

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Abstract: On the basis of two recently collected specimens from Meghalaya state in north-eastern India, we report the occurrence of the monotypic vespertilionid genus *Eudiscopus* in the Indian Subcontinent. This taxon has so far been known only from a few localities in Southeast Asia. Our records also constitute a westward range extension of *E. denticulus* by about 1000 km into eastern South Asia. We provide comparative mensural data of several museum specimens of *E. denticulus* from Southeast Asia. Additionally, the echolocation call and wing characteristics of this species from Meghalaya are also described. The higher call frequency and lower wing loading and aspect ratio of the Indian *E. denticulus* indicate adaptation to cluttered environment, corroborating its guild assignment as edge space aerial forager. Molecular comparisons of the mitochondrial cytochrome *b* gene sequence with samples from Vietnam revealed no genetic variation, despite large geographic distances separating the samples. Phylogenetic reconstructions confirm that *Eudiscopus* is a basal Myotinae, but its position relative to *Submyotodon* and *Myotis* is still uncertain.

Keywords: Phylogeny - Myotinae - echolocation - wing morphology - India.

Résumé: En se basant sur deux spécimens découverts dans l'état du Meghalaya, au nord-est de l'Inde, nous révélons l'existence d'*Eudiscopus denticulus* pour la première fois dans le sous-continent indien. Ce genre monotypique n'était connu que de quelques localités en Asie du Sud-Est. Cette découverte au Meghalaya étend par conséquent l'aire connue pour cette espèce de près de 1000 km vers l'ouest. Des données biométriques comparatives avec des spécimens d'Asie du Sud-Est sont présentées. De même, les cris d'écholocation et la morphologie alaire d'*E. denticulus* du Meghalaya sont aussi analysés. Une combinaison de signaux ultrasonores particulièrement brefs et aigus, ainsi qu'une faible charge alaire couplée à des ailes relativement larges suggèrent qu'*E. denticulus* est adapté à chasser dans des milieux encombrés, ce qui corrobore son classement dans cette guilde de chauves-souris insectivores. Des séquences mitochondriales du gène cytochrome *b* sont aussi comparées avec des échantillons vietnamiens et malgré la grande distance géographique qui les sépare, elles ne révèlent aucune différence génétique. Les reconstructions moléculaires basées sur ce marqueur démontrent que le genre *Eudiscopus* fait bien partie d'une lignée basale parmi les Myotinae, mais sa position exacte relativement aux genres *Submyotodon* et *Myotis* reste ambiguë.

Mots-clés: Phylogénie - Myotinae - écholocation - morphologie alaire - Inde.

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INTRODUCTION

The Disk-footed bat, *Eudiscopus denticulus* (Osgood, 1932), is an Oriental species known from a few localities in Myanmar, Thailand, Laos, and Vietnam (Soisook *et al.*, 2016), and in Yunnan, China (Yu *et al.*, 2021). It was originally described as *Discopus denticulus* based on several specimens captured from Phong Saly (Phongsali) in northernmost Laos (Osgood, 1932) but later allocated to the genus *Eudiscopus* as the former was found to be preoccupied (Conisbee, 1953). This enigmatic species of Vespertilionidae has been allocated variously to the subfamily Vespertilioninae (Tate, 1942; Simmons, 2005; Görföl *et al.*, 2019), or, more commonly, as a member of the Myotinae, with uncertain position (Borissenko & Kruskop, 2003; Tsytsulina *et al.*, 2007; Borisenko *et al.*, 2008; Yu *et al.*, 2014; Amador *et al.*, 2018;). In view of its relatively wide distribution, the IUCN categorized it as Least Concern although nowhere it is a common species and it is rarely found in museum collections (Tsytsulina *et al.*, 2007; Soisook *et al.*, 2016; Haslauer, 2019; Yu *et al.*, 2021). In this paper, based on two new specimens collected from Meghalaya state in north-eastern India, we provide the first evidence of this species in the Indian Subcontinent together with comparative data of this species from Southeast Asia. Echolocation call characteristics of a free flying animal and its wing morphology in relation to ecology are also discussed. Finally, we compare a fragment of the mitochondrial cytochrome *b* gene sequenced from a Meghalaya specimen with samples from Vietnam and place this lineage of *Eudiscopus* in a more general phylogenetic context.

MATERIALS AND METHODS

Two individuals of *Eudiscopus denticulus* from Meghalaya were captured with mist nets set in a forest patch of overgrown bamboo adjacent to the Nongkhyllem Wildlife Sanctuary, in Ri-Bhoi district of Meghalaya, India (25°56'13"N, 91°46'24"E, 210 m a.s.l.), on July 1st 2020. Animals were handled following standard methods in mammalogy (Sikes *et al.*, 2016) and kept as vouchers in the collection of the Zoological Survey of India, Shillong (ZSI) for further morphologic and genetic examinations. For morphological comparisons with extra-Indian material, collections of the following institutions were consulted: AMNH, The American Museum of Natural History, New York, USA; BM(NH), The Natural History Museum [formerly British Museum (Natural History)], London, UK; HNHM, Hungarian Natural History Museum, Budapest, Hungary; IEBR, Institute of Ecology and Biological Resources, Hanoi, Vietnam; MHNG, Natural History Museum of Geneva, Switzerland; ZMMU, Zoological Museum of Moscow State University, Moscow. The examined *E. denticulus* specimens included the type from Laos [BM(NH) 40.819] and 18 other individuals from Southeast Asia as follows: Myanmar, Pegu – AMNH 54789 and 54790 (2 females); Vietnam, Pu Huong – IEBR PH8, 10, 14-18, 20, 23, 31 and 33 (unsexed), and HNHM 2008.23.12., 2012.30.29., 2012.30.30., 2012.30.31., 2012.30.32 (3 females and 2 males).

Animals were characterized biometrically with 11 external and 14 craniodental morphological characters. Except for hindfoot length (HF) which included claws, the standard external measurements were taken as defined by Bates & Harrison (1997) and taken to the nearest 0.1 mm with a dial calliper. These external measurements were forearm length (FA), tail length (TL), head and body length (HB), tibia length (TB), ear length (E), tragus length (TR), length of the three respective metacarpals (3mt to 5mt) and body mass (W, expressed in grams). For vouchered specimens, craniodental measurements were also taken with a digital calliper (to the nearest 0.01 mm) and also corresponded to those proposed by Bates & Harrison (1997): greatest length of skull including incisors (GTLi); condylo-canine length (CCL); zygomatic width (ZW); breadth of the cranium measured between the mastoids (MAB); breadth of braincase (BB); minimum width of postorbital constriction (POC); height of the skull (SKH); maxillary toothrow length (CM^3); width across the upper molars (M^3-M^3); width across the upper canines (C^1-C^1); length of upper molar toothrow (M^1-M^3); mandible length, including incisors (MLi); mandibular toothrow length (CM_3) and height of the coronoid process (COH). We traced the outline of the right wing of the adult female on a paper sheet with 10 x 10 mm grids before *rigor mortis* was achieved and subsequently analysed a digital scan of the tracing using Image J (Schneider *et al.*, 2012). We measured total area, hand wing area and arm wing area thrice and took the mean to reduce error in our measurements. Length measurements (wingspan, hand wing length and arm wing length) were measured only once. From the wing tracing, we calculated wing loading, aspect ratio and tip-shape index for the adult female individual following Norberg & Rayner (1987).

Echolocation calls of free flying bats were recorded at the sampling site with an Anabat Walkabout detector (Titley Scientific, Brendale, Australia) with the microphone pointing towards the tunnel-like structure formed by the bamboo thicket. Calls were recorded just prior to the capture of two *E. denticulus* in the mist net. The recordings were analysed on Raven Pro 1.5.0 (Cornell Lab of Ornithology, Ithaca, USA) and statistics derived from 20 pulses representing search phase calls (i.e. with short terminal narrowband FM tails). Call parameters included start frequency (highest frequency, SF), end frequency (lowest frequency, EF), peak frequency with maximal energy (PF), bandwidth (BW) and duration (D) and were measured from a spectrogram of FFT size 1024 and a Hanning window.

To confirm species identification and further compare genetically the Indian specimens with other available

Disk-footed bats, we extracted DNA from an ethanol-preserved tissue sample from the adult female from Meghalaya (ZSI VMERS 621), and from two further *E. denticulus* specimens collected in Bu Gia Map NP, southern Vietnam (ZMMU S-184645 and S-184651; Kruskop, 2010). We also extracted DNA from a range of various other Vespertilionidae and Miniopteridae outgroups (Table 1). Whole DNA was extracted with the DNAeasy Blood and Tissue Kit (QIAGEN) following manufacturer's instructions and eluted in a final volume of 60 to 200 µl of TE buffer. We either amplified the whole mitochondrial cytochrome *b* gene with standard procedures (detailed e.g. in Sedlock *et al.*, 2020) or a shorter fragment of 421 bp with the primer pair mcb398 and mcb869, as described in Verma & Singh (2003). The PCR products were purified with exonuclease-I and shrimp alkaline phosphatase (Thermo Scientific Inc.) and sequenced with Sanger technology in both directions, using the same amplification primers. Chromatograms of the sequenced fragments were inspected visually to ensure that they did not contain double peaks or stop codons reminiscent of pseudogenes and were then aligned with the program Sequencher 4.8 (Gene Codes, Co). All new sequences were deposited in the GenBank (accession numbers MW491233 - MW491242).

To place the sequenced Disk-footed bats in a phylogenetic framework, we further downloaded from the GenBank a set of homologous sequences (see Table 1) representing a collection of Asian Myotinae, including all known *Submyotodon* species, five members of the closely related Kerivoulinae - Murininae, and other unrelated vespertilionids bearing more or less developed thumb or wrist pads (Csorba *et al.*, 2015). The aligned sequences were submitted to a maximum likelihood phylogenetic reconstruction with the program iQ-TREE v2.1.2 (Nguyen *et al.*, 2015). We used a fully partitioned model with three codon positions and the most appropriate substitution model for each partition, as identified by ModelFinder (Kalyaanamoorthy *et al.*, 2017). Branch support for this approach was evaluated with 1000 Ultrafast bootstraps (Hoang *et al.*, 2018). Similarly, Bayesian phylogenetic reconstruction were also performed on the same data set with a fully partitioned model, using MrBayes v3.2.7 (Ronquist *et al.*, 2012). Four independent MCMC chains were run for four million generations, sampling trees every thousand generation. Posterior probability support of nodes from the final consensus tree was obtained by removing the initial 10 K trees as burn-in.

RESULTS AND DISCUSSION

Description of the new Indian specimens

The two captured Disk-footed bats, one adult female (FA 33.5 mm) and another juvenile female (FA 33.9 mm) were netted in a forest patch dominated by bamboo thicket. They were recognized as *Eudiscopus denticulus* (Osgood, 1932) owing to a combination of small size, conspicuous disk-like pads present on their feet and a *Myotis*-like tragus shape (Fig. 1). There were remarkable differences in pelage colour between the juvenile and adult individuals, the former (Fig. 1C) being much darker than the latter (Fig. 1A and B). The adult female had a bright reddish-brown pelage, except for the belly which was darker with paler tips. The individual hairs had darker roots both dorsally and ventrally. This colouration is thus brighter reddish brown as against cinnamon brown given in the original description of the species from Laos (Osgood, 1932) or to specimens from Vietnam (e.g. Kruskop, 2013). However, as noted by Koopman (1972) the Myanmar specimens were smaller and brighter than Laos specimens and our Meghalaya specimen thus resembles the Myanmar material in pelage colour and shorter forearm (Table 2). The wing membrane was dark brown and essentially devoid of hairs and joined at the base of the outer toe. The tail tip was completely enclosed within the interfemoral membrane which was little lighter in colour and slightly whitish on the underside. The muzzle was pinkish. The ears were relatively large and pointed, unlike those of e.g. *Tylonycteris* or *Glischropus*, whereas the tragus was straight with a concave outer border and blunt tip, much like that of a small *Myotis*. The thumbs were short (1.5 mm) and there were callosities at the thumb base which were dark pigmented and not very obvious. Schliemann & Rehn (1980) noted that these poorly differentiated thumb pads unlikely have adhesive function in *Eudiscopus*, unlike in *Tylonycteris* or *Glischropus*. Noticeable planter pads existed in the form of sub-rectangular adhesive discs (4 x 2.9 mm) which were dark pink in colour (Fig. 1B) and turning beige in ethanol-preserved specimens. This disc development was more pronounced than in *Tylonycteris* as noted by Schliemann & Hoeber (1978). The juvenile individual (as determined from less knobby and evenly tapered phalangeal-metacarpal joints) was externally similar to the adult one in all respects except that the pelage was dark brown (Fig. 1C).

The skull was very broad and flat (Fig. 2A and B); however, unlike *Tylonycteris*, rostrum was longer and narrower. The zygomatic arches were widely flared (ZW 9.7 mm). The coronoid process of mandible was high and blunt with concave posterior border (Fig. 2C). The upper incisors were bicuspid and similar in height and separated from the canine by a small gap. The canine was unicuspid and considerably exceeded the length of the third premolar. There were three pairs of lower premolars, the middle one (p_3) being minute and completely displaced internally. In our specimen, the anterior teeth of the mandible were shed during the chemical cleaning process but not before being able to examine the dental structure. Lower molars were all myotodont, as in most *Myotis* or *Tylonycteris*, but unlike in *Glischropus* (Kruskop, 2013).

Table 1. Species sampling for the molecular reconstructions based on the mitochondrial cytochrome *b* gene with corresponding museum voucher (if any), country of origin, GenBank entries and reference of the published sequences.

Species	Voucher	Origin	GenBank	Reference
Eudiscopus denticulus	ZMMU S-184645	Vietnam	MW491233	This study
Eudiscopus denticulus	ZMMU S-184651	Vietnam	MW491234	This study
Eudiscopus denticulus	ZSI VMERS 621	NE India	MW491242	This study
Glischropus aquilus	MZB 35030	Indonesia	KR612333	Csorba *et al.* (2015)
Glischropus bucephalus	HNHM 2006.34.45	Cambodia	KR612332	Csorba *et al.* (2015)
Glischropus bucephalus	HNHM 21735	Cambodia	MW491235	This study
Glischropus bucephalus	HNHM 21736	Cambodia	MW491236	This study
Glischropus tylopus	MHNG 1970.063	Malaysia	JX570898	Heaney *et al.* (2012)
Hesperoptenus blanfordi	CPV10x40	Cambodia	MF038482	Hassanin *et al.* (2018)
Hesperoptenus blanfordi	MHNG 1970.053	Malaysia	MW491237	This study
Hesperoptenus tickelli	CPV10x21	Cambodia	MF038483	Hassanin *et al.* (2018)
Kerivoula kachinensis	ZSI VMERS 571	NE India	JQ044697	Ruedi *et al.* (2012)
Kerivoula whiteheadi	FMNH 177475	Philippines	MG194438	Sedlock *et al.* (2020)
Miniopterus fuliginosus	ZSI M2262	NW India	MW054886	Ruedi *et al.* (2021)
Miniopterus magnater	MHNG 1981.071	NE India	MW054887	Ruedi *et al.* (2021)
Miniopterus medius	MHNG 1970.051	Malaysia	MW491238	This study
Miniopterus pusillus	ZSI VMERS 570	NE India	MW054888	Ruedi *et al.* (2021)
Murina cyclotis	MHNG 1981.072	NE India	JQ044691	Ruedi *et al.* (2012)
Murina pluvialis	ZSI VMERS 603	NE India	JQ044689	Ruedi *et al.* (2012)
Myotis alticraniatus	MHNG 1956.090	Laos	KF312531	Ruedi *et al.* (2013)
Myotis annamiticus	ZMMU S-167134	Vietnam	KF312499	Ruedi *et al.* (2013)
Myotis annatessae	MHNG 1926.044	Laos	KF312514	Ruedi *et al.* (2013)
Myotis cf. *ater*	MHNG 1926.036	Laos	KF312509	Ruedi *et al.* (2013)
Myotis blythii	ZSI VMERS 405	NW India	MW054872	Ruedi *et al.* (2021)
Myotis brandtii	-	Asia	KM199849	Jiang *et al.* (2016)
Myotis davidii	KM 13093	S Korea	AY665148	Tsytsulina *et al.* (2012)
Myotis fimbriatus	HNHM 25872	S China	MW054893	Ruedi *et al.* (2021)
Myotis horsfieldii	ZMMU S-165039	Vietnam	MW491239	This study
Myotis ikonnikovi	-	S Korea	KF111724	Yoon *et al.* (2015)
Myotis longipes	ZSI M2210	NW India	MW054878	Ruedi *et al.* (2021)
Myotis mystacinus	MHNG 3003.057	Europe	MW054880	Ruedi *et al.* (2021)
Myotis nipalensis	CDZTU B9	Nepal	MW054894	Ruedi *et al.* (2021)
Myotis phanluongi	ZMMU S-175154	Vietnam	KF312525	Ruedi *et al.* (2013)
Myotis rosseti	ROM 110487	Laos	KF312527	Ruedi *et al.* (2013)
Myotis rosseti	ZMMU S-175291	Vietnam	MW491240	This study
Myotis sibiricus	Mbra26RU	C Russia	MG897530	Kocacova *et al.* (2018)
Myotis siligorensis	ZSI VMERS 601	NE India	MW054883	Ruedi *et al.* (2021)
Phoniscus jagorii	FMNH 202818	Philippines	MG194467	Sedlock *et al.* (2020)
Scotozous dormeri	MHNG 1947.073	S India	MW491241	This study
Submyotodon caliginosus	ZSI VMERS 421	NW India	MW054884	Ruedi *et al.* (2021)
Submyotodon latirostris	M608	Taiwan	AM262330	Stadelmann *et al.* (2007)
Submyotodon moupinensis	HNHM 26564	S China	MW054895	Ruedi *et al.* (2021)
Tylonycteris fulvida	MHNG 1926.055	Laos	KX496526	Tu *et al.* (2017)
Tylonycteris malayana	CPV10-503	Cambodia	KX496369	Tu *et al.* (2017)
Tylonycteris tonkinensis	MHNG 1926.059	Laos	KX496441	Tu *et al.* (2017)

Table 2. Comparative measurements of the two *E. denticulus* from Meghalaya and 18 other individuals from Southeast Asia. External measurements were taken from both Meghalaya individuals, while only the adult female was measured for craniodental characters. Values in brackets are means.

Measurements (in mm)	Meghalaya (n = 2)	Type from Laos (n = 1)	SE Asia (n = 18)
W (g)	3, 5	-	4.5-5.0 (4.8)
HB	36.5, 40	43	35.9-40.5 (38)
TL	37, 38	40	34.9-41.2 (38.6)
HF	6.8	6.2	5.8-7.2 (6.6)
TB	15.5	17.2	15.4-16.9 (16.3)
E	11.5, 11.7	-	10.9-12.5 (11.6)
TR	4.7, 5.2	-	5.6-5.9 (5.7)
FA	33.5, 33.9	37.8	33.5-36.6 (34.5)
3mt	32	34.2	31.3-33.2 (32.3)
4mt	31.3	32.6	30.4-32.0 (31.0)
5mt	31.2	32.2	30.4-32.4 (31.3)
GTLi	14.00	14.2	13.43-14.49 (13.99)
CCL	12.50	13.2	12.15-13.16 (12.75)
ZW	9.58	9.7	8.97-9.43 (9.21)
MAB	7.52	7.7	7.20-7.81 (7.51)
BB	6.70	7.0	6.36-6.99 (6.72)
POC	3.77	3.6	3.40-3.94 (3.61)
SKH	3.94	3.5	3.07-3.97 (3.67)
CM^3	5.11	5.4	5.20-5.49 (5.35)
M^3-M^3	5.60	5.8	5.74-6.05 (5.83)
C^1-C^1	3.62	3.8	3.59-3.91 (3.71)
M^1-M^3	3.61	-	-
MLi	10.10	10.6	9.74-10.63 (10.20)
CM_3	5.28	5.5	5.49-5.85 (5.68)
COH	3.26	-	3.00-3.38 (3.15)

Revised distribution

So far, the species was reported from several localities in Southeast Asia *i.e.* Yetho River, Pegu Yoma in central Myanmar (Koopman, 1970); Khlong Lan National Park, Loei, Ratchaburi, and Surat Thani in Thailand (Schliemann & Kock, 2000; Soisook *et al.*, 2016), and Chu Mom Ray in Kon Tum Province in central, Cat Tien National Park in the south and Pu Huong, and Bu Gia Map Nature Reserve in north-central Vietnam (Borissenko & Kruskop 2003; Zsebők *et al.*, 2014; Kruskop, 2013, 2017). Very recently, it has also been reported from three localities in Yunnan Province of China (Yu *et al.*, 2021). According to Koopman (1970, 1972), the precise locality of two specimens from Myanmar housed in the AMNH *i.e.* "Yetho River, Pegu Yoma, 100ft" is indeterminate. This was confirmed by Schliemann & Kock (2000) who also noted that within a radius of 100 km, there are at least three low-elevation localities (under 50 m a.s.l.) named "Yetho" in the slopes of Pegu mountains in Myanmar and one of these places might represent the source of the Myanmar's specimens. In our view also, this locality represents a tributary of Sittuang river in south-central Myanmar and lies in the same general area (18° 00' - 18° 05'N, 96° 00'- 96° 05'E) as postulated by Schliemann & Kock (2000) and was hitherto considered the westernmost locality for this species. The present locality in Meghalaya thus represents a range extension of about 1000 km further west into the Indian Subcontinent (Fig. 3) and was not predicted to occur in this region according to the MaxEnt modelling study of Yu *et al.* (2021). Furthermore, except for the type locality which is situated at an altitude of about 1300 m a.s.l. in northern Laos (Schliemann & Rehn, 1980), all records of Disk-footed bats lie below 1000 m a.s.l., including the present record from north-eastern India (210 m a.s.l.), suggesting that this is a predominantly lowland species.

Ecological notes

The two Meghalaya Disk footed bats were caught in a net set at one of the entrances of a tunnel-like closed canopy forest with predominant bamboo growths (*Dendrocalamus* and *Bambusa* spp.). The general forest habitats found in the area belongs to Tropical semi-evergreen type (Champion & Seth, 1968). These bats were caught on the inner side of the net indicating they were emerging from inside the forest patch. By virtue of remarkable morphological features like a flattened skull and adhesive pads, these bats can roost inside cramped space clinging to smooth surfaces like bamboo internodes (Koopman, 1972; Kock & Kovac, 2000; Schliemann & Kock, 2000). Considering the bamboo-dominated forest from where these specimens were collected, a similar roosting preference can be expected in Meghalaya. A knowledgeable villager indicated occasional presence of bats inside bamboo internodes. However, he indicated that they were not as bright in colouration, possibly referring to other bamboo-dwelling bats (*Tylonycteris* spp.) which were also recorded by the senior author from the nearby Nongkhyllem WLS during bat surveys conducted in 2016. This indicates uncommon occurrence of *Eudiscopus* in the area. Similar observations were also reported by Kock & Kovac (2000) who found *E. denticulus* only once in Thailand, after numerous probing in bamboo internodes in Southeast Asia, whereas *Tylonycteris* spp. were frequently recorded.

Echolocation

The echolocation call parameters (mean ± standard deviation) were as follows: SF = 104.82 ± 2.7 kHz, EF = 53.12 ± 5.79 kHz, PF = 56.81 ± 2.86 kHz, BW = 51.69 ± 2.55 kHz and D = 4.75 ± 0.63 ms. These parameters and the entire call structure (Fig. 4) are similar to those previously recorded for *E. denticulus* (Hughes *et al.*, 2011; Zsebők *et al.*, 2014). Although we could not completely rule out the possibility of these recorded calls belonging to another species, it is most probable that the calls belong to *E. denticulus*. During the three hours of netting session at the site, the only other species caught were *Rhinolophus affinis* (emitting very distinct, constant-frequency signals) and *Pipistrellus coromandra*. Considering the rhythm and frequency range of the recorded calls which are much higher than those reported for *P. coromandra* elsewhere (Srinivasulu *et al.*, 2017), we can exclude confusion with this species

Fig. 1. Lateral (A) and frontal (B) view of an adult female (ZSIS 621) and lateral view (C) of juvenile (ZSIS 622) *E. denticulus* specimen from Meghalaya (images not to scale). Notice prominent pinkish plantar disc on the hind feet (image B).

as well. We did not record the long, upward-sweeping "unique call type" described by Zsebők *et al.* (2014) for *E. denticulus*. However, we recorded prominent hook-shaped starts in two pulses (as seen in some *Kerivoula* and *Murina* spp.; Schmieder *et al.*, 2010) that were not mentioned earlier (Fig. 4).

Wing morphology

Wing morphology and echolocation calls are a reliable method to assign guild membership to bats (Norberg & Rayner, 1987; Denzinger & Schnitzler, 2013) and also allow to predict the potential vulnerability of species to anthropogenic disturbance (Núñez *et al.*, 2019). However, these data are mostly lacking for tropical bat species, particularly those rare species like *E. denticulus*. Based on measurement of the adult female caught in Meghalaya, the moderate aspect ratio (6.64) and low wing loading (5.55) coupled with relatively broad tips (Tip-shape index = 1.68) indicate low flight speed and improved manoeuvrability (Norberg & Rayner, 1987). On account of these novel wing morphology data and relatively high echolocation call frequency, we corroborate Zsebők *et al.* (2014)'s guild assignment of *E. denticulus* as an 'edge space aerial forager' (Denzinger & Schnitzler, 2013) that can adapt to a fair degree of clutter (as bamboo forests in this case). With such wing and echolocation call characteristics it appears less well adapted to forage in complete open space. We indeed observed the flight of the juvenile individual inside a large room performing a slow, fluttering flight similar to those of some *Pipistrellus* spp.

Genetics

The partial cytochrome *b* gene was successfully amplified and sequenced from the adult female *E. denticulus* from Meghalaya. Remarkably, the 421 aligned base pairs of this individual were identical to homologous sequences of *E. denticulus* from Vietnam, despite the over 2000 km straight distance separating the two sampling localities. Both individuals from Vietnam sequenced for the complete cytochrome *b* (1140 bp) were also nearly identical, with a single T/C transition noted in position 996. The comparison of various individuals sequenced for another mitochondrial gene (the cytochrome c oxidase subunit I) likewise suggest minimal (<1%) molecular variation in Disk-footed bats issued from distant places in

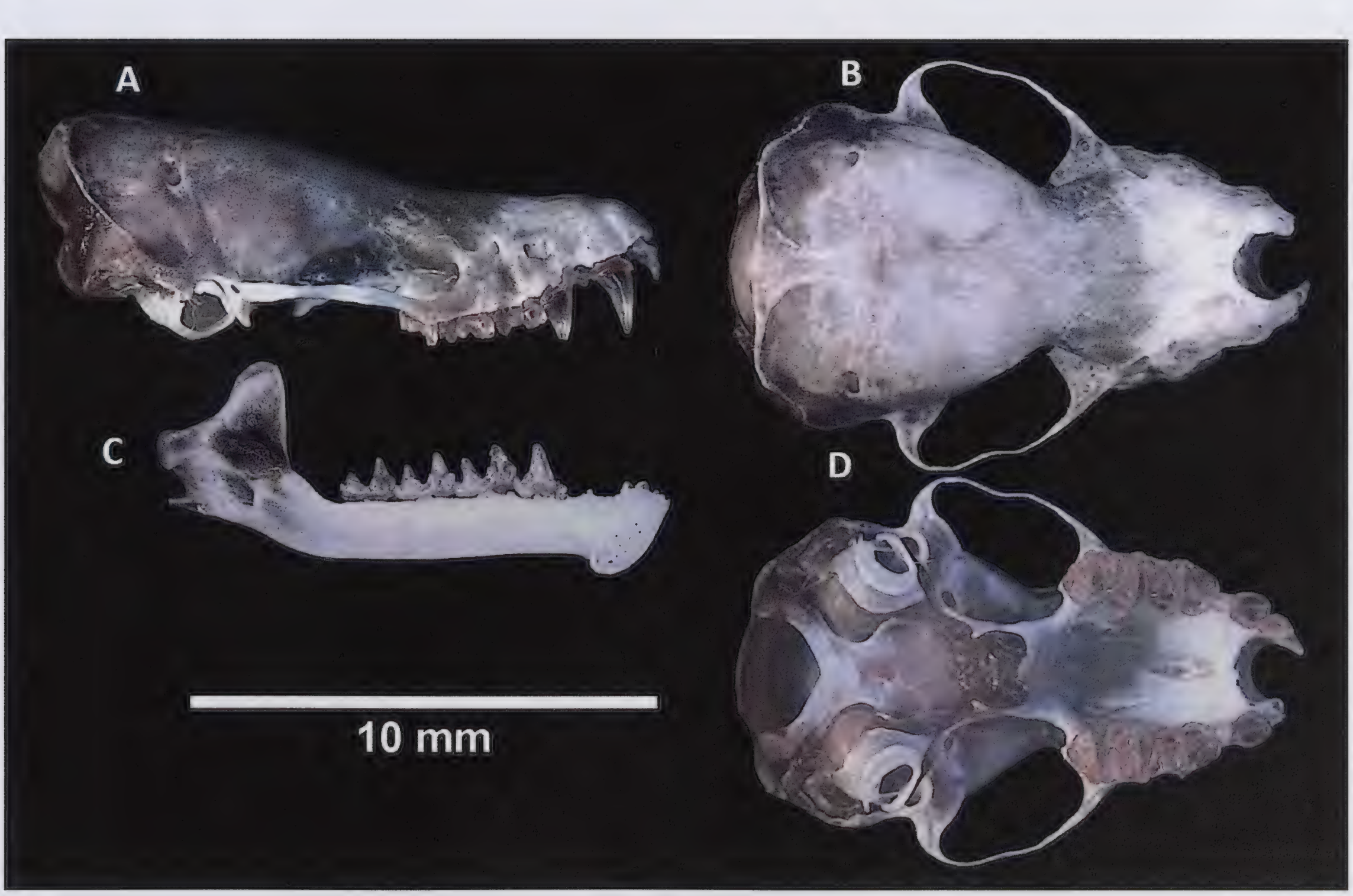

Fig. 2. Lateral (A), dorsal (B), ventral (D) view of cranium and of mandible (C) of ZSIS 621 specimen. Note that the mandibular dentition is incomplete due to inadvertent loss of few anterior teeth (incisors and canines) during the cleaning process of the skull.

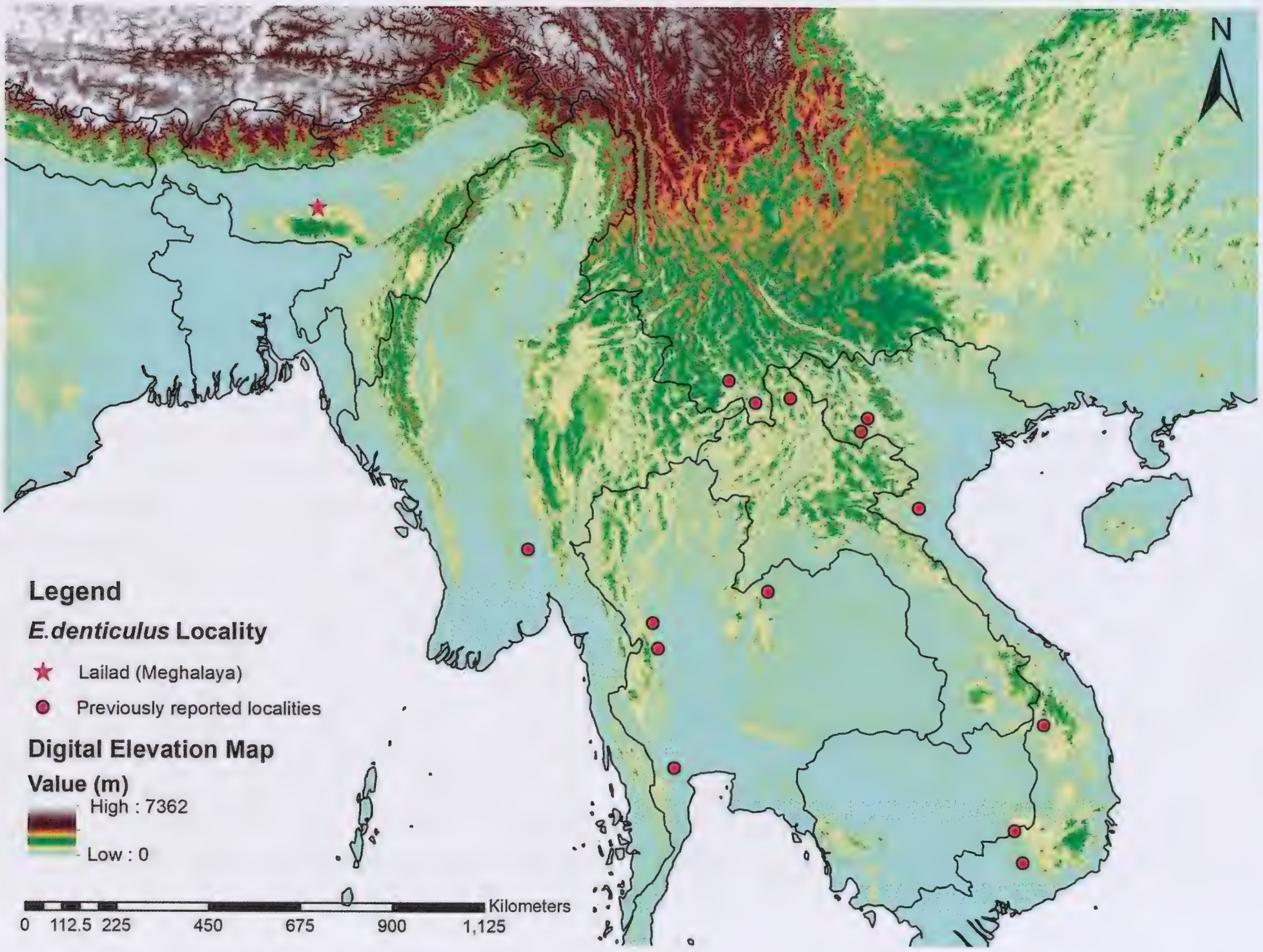

Fig. 3. Location of currently known records of *E. denticulus* in South and Southeast Asia.

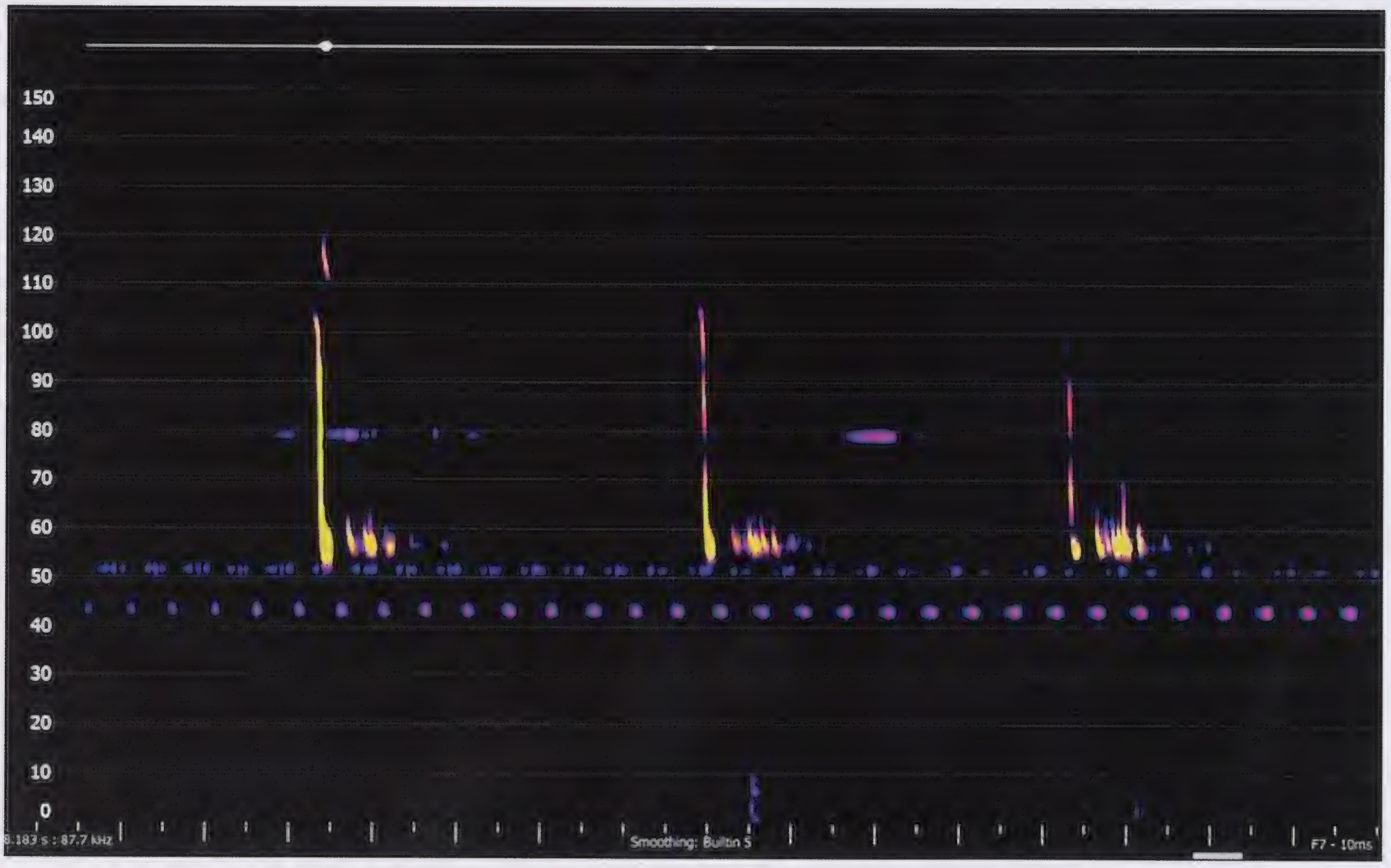

Fig. 4. Call spectrogram of a free flying individual of *E. denticulus* from Meghalaya. The values in the vertical axis indicate call frequency in kHz. Each division of the horizontal axis indicates a time interval of 10 milliseconds.

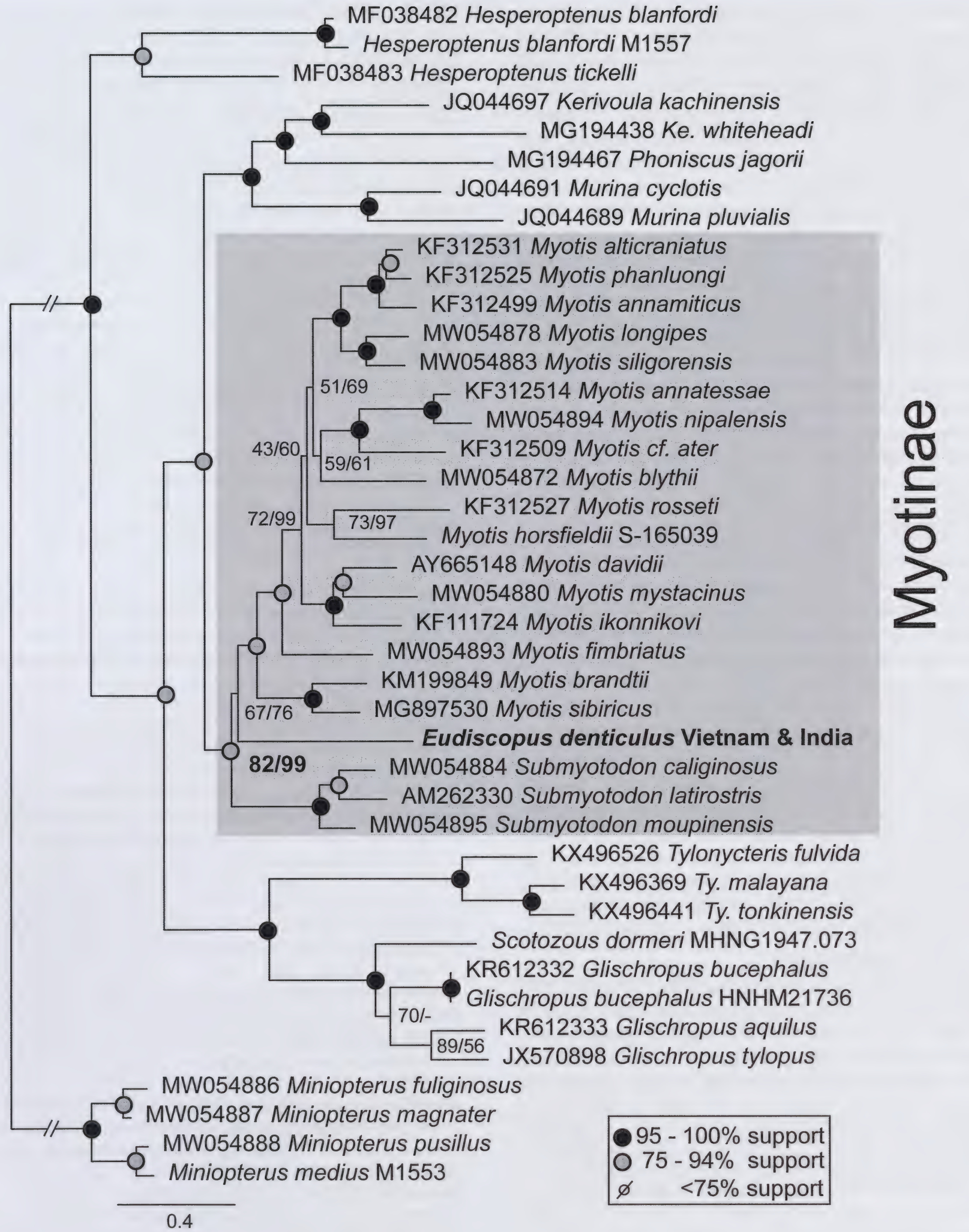

Fig. 5. Maximum likelihood reconstruction of the *Eudiscopus denticulus* lineage within a selection of Vespertilionidae and outgroup Miniopteridae bats. Percent nodal support obtained from 1000 Ultrafast repeats in iQ-tree and posterior probabilities in MrBayes are indicated at each node. The actual percentages are given near each node which received less than 75% support, whereas shades of grey are used when both reconstruction methods retrieved higher support for the same node. The newly sequenced *M. rosseti* (ZMMU S-175291) and *G. bucephalus* (HMNH 21735) are not represented here, as they were identical to conspecifics.

Vietnam (Kruskop *et al*., unpublished 2018) or in Yunnan, China (Yu *et al*., 2021). Such high genetic similarities for mitochondrial genes characterized by relatively high mutation rates in mammals, including bats (Bradley & Baker, 2001) suggest that *Eudiscopus* populations from Vietnam, China and Meghalaya certainly have a very recent common origin. As secondary bamboo regrowth has been greatly favoured by the adoption of slash-and-burn culture by expanding human population in Indochina, one hypothesis would be that these bat populations expanded from the same region, following the very recent expansion of man-made bamboo groves.

Compared to other cytochrome *b* from various bat species (Table 1), these sequences of *E. denticulus* differ by at least 18% Kimura-two-parameter distance from any other *Myotis* or *Submyotodon* tested, and by 19% or more from other Vespertilionidae. All phylogenetic reconstructions based on this gene were very concordant and clearly placed the single *Eudiscopus* lineage within the Myotinae, with 82 (maximum likelihood) to 99% (Bayesian) support (Fig. 5). Unfortunately, these reconstructions could not resolve the relative position of *Eudiscopus* in this radiation, as the other two Myotinae, *Myotis* and *Submyotodon*, were also placed near the base of this radiation with low nodal support. A basal position of *Eudiscopus* within the Myotinae corroborate previous molecular reconstructions based on a small selection of Vespertilionidae and the 12S rDNA sequences (Borisenko *et al*., 2008). The recent and more extensive sampling of the mitochondrial genome of several Vespertilionidae also concluded that *Eudiscopus* was the most basal Myotinae (Yu *et al*., 2021), but clearly, genes from the nuclear genome are needed to completely resolve this radiation. At least, alternative phylogenetic hypotheses placing *Eudiscopus* with other bats bearing enlarged or disk-like pads (e.g. *Glischropus* spp., *Tylonycteris* spp., *Hesperoptenus* spp. or *Myotis rosseti*) or close to other Vespertilioninae can be clearly excluded by current molecular reconstructions.

Despite the relatively small geographic area of the state of Meghalaya, this discovery of a new genus in the country both confirm that this region is exceptionally rich in Chiropteran diversity, and certainly is still underexplored (Ruedi *et al*., 2012). With the present addition of *E. denticulus* from Meghalaya, the reported bat diversity of the state has increased to 66 species and that of India to 130 species (Saikia, 2018; Saikia *et al*., 2018; Chakravarty *et al*., 2020; Ruedi *et al*., 2021).

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REFERENCES

Amador L.I., Arevalo R.L.M., Almeida F.C., Catalano S.A., Giannini N.P. 2018. Bat systematics in the light of unconstrained analyses of a comprehensive molecular supermatrix. *Journal of Mammalian Evolution* 25: 37-70.

Bates P.J.J., Harrison D.L. 1997. Bats of the Indian Subcontinent. *Harrison Zoological Museum, Sevenoaks, UK*, 258 pp.

Borissenko A.V., Kruskop S.V. 2003. Bats of Vietnam and adjacent territories. An identification manual. *Moscow, Russia*, 203 pp.

Borisenko A.V., Kruskop S.V., Ivanova N.V. 2008. A new mouse-eared bat (Mammalia: Chiroptera: Vespertilionidae) from Vietnam. *Russian Journal of Theriology* 7: 57-69.

Bradley R., Baker R. 2001. A test of the genetic species concept: cytochrome *b* sequences and mammals. *Journal of Mammalogy* 82: 960-973.

Champion H.G., Seth S.K. 1968. A revised survey of the forest types of India. *Manager of Publications, Government of India, New Delhi*, 404 pp.

Chakravarty R., Ruedi M., Ishtiaq F. 2020. A recent survey of bats with descriptions of echolocation calls and new records from the western Himalayan region of Uttarakhand, India. *Acta Chiropterologica* 22: 197-224.

Conisbee L.R. 1953. Genera and subgenera of recent mammals. *British Museum (Natural History), London, UK*, 109 pp.

Csorba G., Görföl T., Wiantoro S., Kingston T., Bates P.J.J., Huang J.C.-C. 2015. Thumb-pads up: a new species of thick-thumbed bat from Sumatra (Chiroptera: Vespertilionidae: *Glischropus*). *Zootaxa* 3980: 267-278.

Denzinger A., Schnitzler H.U. 2013. Bat guilds, a concept to classify the highly diverse foraging and echolocation behaviors of microchiropteran bats. *Frontiers in Physiology*: 1-15.

Görföl T., Furey N.M., Bates P.J.J., Csorba G. 2019. The identity of '*Falsistrellus*' *affinis* from Myanmar and Cambodia and new records of *Hypsugo dolichodon* from these countries. *Acta Chiropterologica* 20: 301-309.

Haslauer R. 2019. *Eudiscopus denticulus*. *In:* Wilson D. E., Mittermeier R. A. (eds). Handbook of the Mammals of the World: Bats. Vol. 9, *Lynx Edicions, Barcelona, Spain*, p. 923.

Hassanin A., Colombo R., Gembu G.-C., Merle M., Tu V.T., Görföl T., Akawa P.M., Csorba G., Kearney T., Monadjem A., Ing R.K. 2018. Multilocus phylogeny and species delimitation within the genus *Glauconycteris* (Chiroptera, Vespertilionidae), with the description of a new bat species from the Tshopo Province of the Democratic Republic of

the Congo. *Journal of Zoological Systematics and Evolutionary Research* 56: 1-22.

Heaney L.R., Balete D.S., Alviola P., Rickart E.A., Ruedi M. 2012. *Nyctalus plancyi* and *Falsistrellus petersi* (Chiroptera: Vespertilionidae) from northern Luzon, Philippines: ecology, phylogeny, and biogeographic implications. *Acta Chiropterologica* 14: 265-278.

Hoang D.T., Chernomor O., von Haeseler A., Minh B.Q., Vinh L.S. 2018. UFBoot2: Improving the ultrafast bootstrap approximation. *Molecular Biology and Evolution* 35: 518-522.

Hughes A., Chutamas S., Bates P., Soisook P., Sritongchuay T., Jones G. 2011. Using echolocation calls to identify Thai bat species: Vespertilionidae, Emballonuridae, Nycteridae and Megadermatidae. *Acta Chiropterologica* 13: 447-455.

Jiang J.-J., Wang S.-Q., Li Y.-J., Zhang W., Yin A.-G., Hu M. 2016. The complete mitochondrial genome of insect-eating Brandt's bat, *Myotis brandtii* (*Myotis*, Vespertilionidae). *Mitochondrial DNA* 27: 1403-1404.

Kalyaanamoorthy S., Minh B.Q., Wong T.K.F., von Haeseler A., Jermiin L.S. 2017. ModelFinder: fast model selection for accurate phylogenetic estimates. *Nature Methods* 14: 587-589.

Kock D., Kovac D. 2000. *Eudiscopus denticulus* (Osgood, 1932) in Thailand with notes on its roost. *Zeitschrift für Säugetierkunde* 65: 121-123.

Koopman K. 1970. A second locality for *Eudiscopus denticulus* (Chiroptera: Vespertilionidae). *Journal of Mammalogy* 51: 191.

Koopman K. 1972. *Eudiscopus denticulus*. *Mammalian Species* 19: 1-2.

Kovacova V., Zukal J., Bandouchova H., Botvinkin A.D., Harazim M., Martínková N., Orlov O.L., Piacek V., Shumkina A.P., Tiunov M.P., Pikula J. 2018. White-nose syndrome detected in bats over an extensive area of Russia. *BMC Veterinary Research* 14: 1-9.

Kruskop S.V. 2010. Preliminary data on the bat fauna of Bu Gia Map National Park (southern Vietnam). *Plecotus et al.* 13: 69-74 [in Russian].

Kruskop S. V. 2013. Bats of Vietnam. Checklist and an identification manual. *Joint Russian-Vietnamese Sciences and Technological Tropical Centre and Zoological Museum of Moscow MV Lomonosov State University, Moscow,* 300 pp.

Kruskop S.V. 2017. Between North and South: provisional data on bats (Mammalia: Chiroptera) from Gia Lai – Kon Tum plateaus. *Journal of Tropical Science and Technology* 14: 59-66

Nguyen L.-T., Schmidt H.A., von Haeseler A., Minh B.Q. 2015. IQ-TREE: A fast and effective stochastic algorithm for estimating maximum-likelihood phylogenies. *Molecular Biology and Evolution* 32: 268-274.

Norberg U.M., Rayner J.M.V. 1987. Ecological morphology and flight in bats (Mammalia; Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. *Philosophical Transactions of the Royal Society of London, Series B* 316: 335-427.

Núñez S.F., López-Baucells A., Rocha R., Farneda F.Z., Bobrowiec P.E.D., Palmeirim J.M., Meyer C.F.J. 2019. Echolocation and stratum preference: key trait correlates of vulnerability of insectivorous bats to tropical forest fragmentation. *Frontiers in Ecology and Evolution* 7: 373.

Osgood W.H. 1932. Mammals of the Kelley Roosevelts and Delacour Asiatic expeditions. *Field Museum of Natural History, Zoological Series*, 18: 193-339.

Ronquist F., Teslenko M., Van Der Mark P., Ayres D.L., Darling A., Hohna S., Larget B., Liu L., Suchard M.A., Huelsenbeck J.P. 2012. MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology* 61: 539-542.

Ruedi M., Biswas J., Csorba G. 2012. Bats from the wet: two new species of Tube-nosed bats (Chiroptera: Vespertilionidae) from Meghalaya, India. *Revue suisse de Zoologie* 119: 111-135.

Ruedi M., Stadelmann B., Gager Y., Douzery E.J.P., Francis C.M., Lin L.-K., Guillén-Servent A., Cibois A. 2013. Molecular phylogenetic reconstructions identify East Asia as the cradle for the evolution of the cosmopolitan genus *Myotis* (Mammalia, Chiroptera). *Molecular Phylogenetics and Evolution* 69: 437-449.

Ruedi M., Saikia U., Thabah A., Görföl T., Thapa S., Csorba G. 2021. Molecular and morphological revision of small Myotinae from the Himalayas shed new light on the poorly known genus *Submyotodon* (Chiroptera: Vespertilionidae). *Mammalian Biology*. (in press)

Saikia U. 2018. A review of chiropterological studies and a distributional list of the bat fauna of India. *Records of the Zoological Survey of India* 118: 242-280.

Saikia U., Thabah A., Chachula O.M., Ruedi M. 2018. The bat fauna of Meghalaya, Northeast India: Diversity and Conservation. *In:* Sivaperuman & Venkataraman (eds), Indian Hotspots: Vertebrate faunal diversity, conservation and management. Vol 2. *Springer Nature Singapore Pvt Ltd.*, pp. 263-286.

Schliemann H., Hoeber M. 1978. The structure and the function of the pads on the thumb and foot of *Tylonycteris*. *Proceedings of the 4th International Bat Research Conference, Nairobi*, p. 39.

Schliemann H., Kock D. 2000. Notes on the rare vespertilionid bat *Eudiscopus denticulus* (Osgood, 1932) (Chiroptera, Vespertilioninae). *Mitteilungenaus den Hamburgischen Zoologischen Museum und Institut* 97: 131-134.

Schliemann H., Rehn C. 1980. Zur Kenntnis der Haftorgane von *Eudiscopus denticulus* (Osgood, 1932) (Mammalia: Microchiroptera: Vespertilionidae). *Zeitschrift für Säugetierkunde* 45: 29-39.

Schmieder D.A., Kingston T., Hashim R., Siemers B.M. 2010. Breaking the trade-off: rainforest bats maximize bandwidth and repetition rate of echolocation calls as they approach prey. *Biology Letters* 6: 604-609.

Schneider C.A., Rasband W.S., Eliceiri K.W. 2012. NIH Image to ImageJ: 25 years of image analysis. *Nature Methods* 9: 671-675.

Sedlock J.L., Heaney L.R., Balete D.S., Ruedi M. 2020. Philippine bats of the genus *Kerivoula* (Chiroptera: Vespertilionidae): Overview and assessment of variation in *K. pellucida* and *K. whiteheadi*. *Zootaxa* 4755: 454-490.

Sikes R.S. *et al.* 2016 Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. *Journal of Mammalogy* 97: 663-688.

Simmons N.B. 2005. Order Chiroptera (pp. 312-529). *In:* Wilson D. E., Reeder D. M. (eds), Mammal species of the world. A taxonomic and geographic reference. *Johns Hopkins University Press, Washington*, 3rd ed.

Soisook P., Csorba G., Bumrungsri S., Francis C.M., Bates P., Kingston T. 2016. *Eudiscopus denticulus*. *The IUCN Red*

List of Threatened Species 2016: e.T8168A22028419. DOI: 10.2305/IUCN.UK.2016-2.RLTS.T8168A22028419.en. Downloaded on 10 July 2020.

Srinivasulu C., Srinivasulu A., Srinivasulu B., Gopi A., Dar T. A., Bates P.J.J., Rossiter S., Jones G. 2017. Recent surveys of bats from Andaman Islands, India: Diversity, distribution and echolocation call characteristics. *Acta Chiropterologica* 19: 419-437.

Stadelmann B., Kunz T.H., Lin L.K., Ruedi M. 2007. Molecular phylogeny of New World *Myotis* (Chiroptera, Vespertilionidae) inferred from mitochondrial and nuclear DNA genes. *Molecular Phylogenetics and Evolution* 43: 32-48.

Tate G.H. 1942. Results of the Archbold expeditions, 47: a review of the vespertilionine bats. *Bulletin of the American Museum of Natural History* 80: 221-297.

Tsytsulina K., Kruskop S., Masuda R. 2007. Taxonomical position of genus *Eudiscopus* (Chiroptera, Mammalia) among vespertilionid bats. *Bat Research News* 44: 309.

Tsytsulina K., Dick M.H., Maeda K., Masuda R. 2012. Systematics and phylogeography of the steppe whiskered bat *Myotis aurascens* Kuzyakin, 1935 (Chiroptera, Vespertilionidae). *Russian Journal of Theriology* 11: 1-20.

Tu V.T., Csorba G., Ruedi M., Furey N.M., Son N.T., Thong V.D., Bonillo C., Hassanin A. 2017. Comparative phylogeography of bamboo bats of the genus *Tylonycteris* (Chiroptera, Vespertilionidae) in Southeast Asia. *European Journal of Taxonomy* 274: 1-38.

Verma S.K., Singh L. 2003. Novel universal primers establish identity of an enormous number of animal species for forensic application. *Molecular Ecology Notes* 3: 28-31.

Yoon K.B., Cho J.Y., Park Y.C. 2015. Complete mitochondrial genome of the Korean Ikonnikov's bat *Myotis ikonnikovi* (Chiroptera: Vespertilionidae). *Mitochondrial DNA* 26: 274-275.

Yu W., Wu Y., Yang G. 2014. Early diversification trend and Asian origin for extent bat lineages. *Journal of Evolutionary Biology* 27: 2204-2218.

Yu W.-H., Csorba G., Huang Z.-L., Li Y.-N., Quan R.-C., Wang Q.-Y., Liu S., Shi H.-Y., Wu Y., Li S. 2021. The first record of the disc-footed bat *Eudiscopus denticulus* (Chiroptera, Vespertilionidae) from China and the resolution of the phylogenetic position of the genus. *Zoological Research* 42: 94-99.

Zsebők S., Son N.T., Csorba G. 2014. Acoustic characteristics of the echolocation call of the disc-footed bat, *Eudiscopus denticulus* (Osgood, 1932) (Chiroptera, Vespertilionidae). *Acta Acoustica united with Acustica* 100: 767-771.

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A new baviine species of the genus *Maripanthus* Maddison from India (Araneae: Salticidae)

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Abstract: A new species of the genus *Maripanthus* Maddison, 2020, *M. gloria* Caleb, sp. nov. (♂♀) is diagnosed and described from the Karnataka State of India. A map showing the distributional records of all known congeners is provided.

Keywords: Taxonomy - jumping spiders - Baviini - Chelekere - Karnataka.

INTRODUCTION

The baviine genus *Maripanthus* was established by Maddison in 2020, with *Maripanthus draconis* Maddison in Maddison *et al*., 2020 as its type species (Maddison *et al*., 2020). In the most recent review of baviines based on morphological and molecular data (Maddison *et al*., 2020) the genus falls in 'the Piranthus clade' along with the only other genus, *Piranthus* Thorell, 1895. Presently the genus consists of five species: *M. draconis* (Singapore, Malaysia and Brunei), *M. jubatus* Maddison in Maddison *et al*., 2020 (India), *M. menghaiensis* (Cao & Li in Cao *et al*., 2016) (China), *M. reinholdae* Maddison in Maddison *et al*., 2020 (Brunei and Malaysia) and *Maripanthus smedleyi* (Reimoser, 1929) (Sumatra) (see Maddison *et al*., 2020; World Spider Catalog, 2021). The present paper gives the detailed description of a new species, *Maripanthus gloria* sp. nov. (♂♀), from Karnataka, India.

MATERIAL AND METHODS

Live specimens were photographed with a Nikon D850 DSLR camera with a Nikkor 105 mm macro lens, illuminated by a mounted Godox 860ii flash light with a diffuser. The morphological examination of specimens was carried out under a Leica SAPO stereomicroscope, micrographs were taken with a Leica MC190 HD camera and processed with the Leica Application Suite (LAS) version 4.13. The epigyne was dissected and cleared in 10% KOH. The temporary slide preparations were examined under a Leica DM3000 LED compound microscope and photographed with a Leica MC190 HD camera. The distribution map was prepared with the online mapping software SimpleMappr (Shorthouse, 2010). Leg measurements are given in the following order: total (femur, patella, tibia, metatarsus, tarsus). All measurements are in millimetres. The type material is kept in the National Zoological Collection, Southern Regional Centre of the Zoological Survey of India (ZSIC), Chennai, and in the research collection of the National Centre for Biological Sciences (NCBS), Bengaluru.
Other abbreviations used in the text: AER = anterior eye row; ALE = anterior lateral eye; AME = anterior median eye; ECP = epigynal coupling pocket; EFL = eye field length; PER = posterior eye row; PLE = posterior lateral eye; PME = posterior median eye; RTA = retrolateral tibial apophysis.

TAXONOMY

Genus *Maripanthus* Maddison in Maddison *et al*., 2020

Type species: *Maripanthus draconis* Maddison in Maddison *et al*., 2020.

Diagnosis: Members are similar to those of *Indopadilla* Caleb & Sankaran in Caleb *et al*., 2019 and *Bavia* Simon, 1877 but differ in lacking the characteristic ridged chelicerae and the thoracic bulges of *Indopadilla* spp. and in possessing a much longer embolus than

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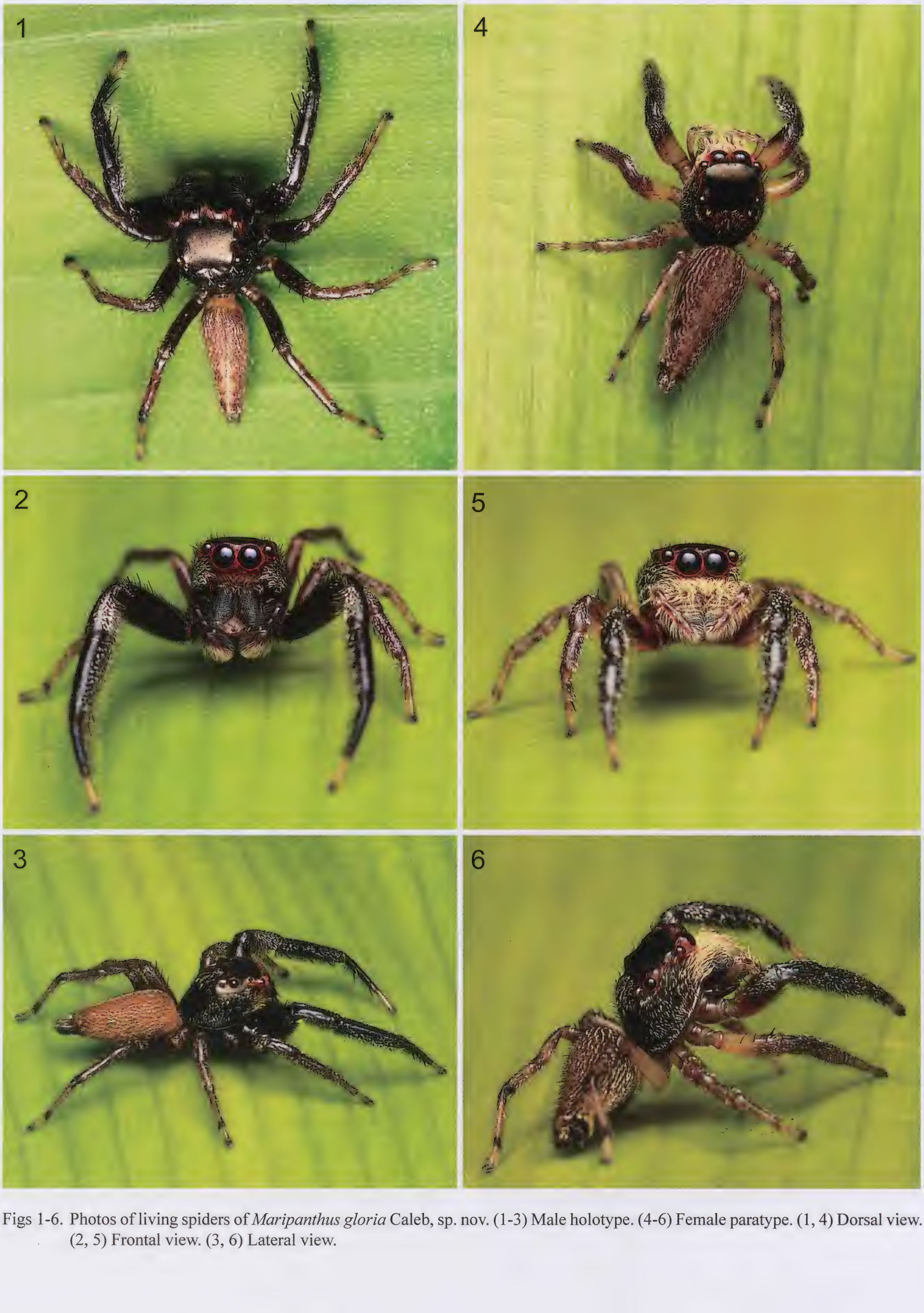


Figs 1-6. Photos of living spiders of *Maripanthus gloria* Caleb, sp. nov. (1-3) Male holotype. (4-6) Female paratype. (1, 4) Dorsal view. (2, 5) Frontal view. (3, 6) Lateral view.

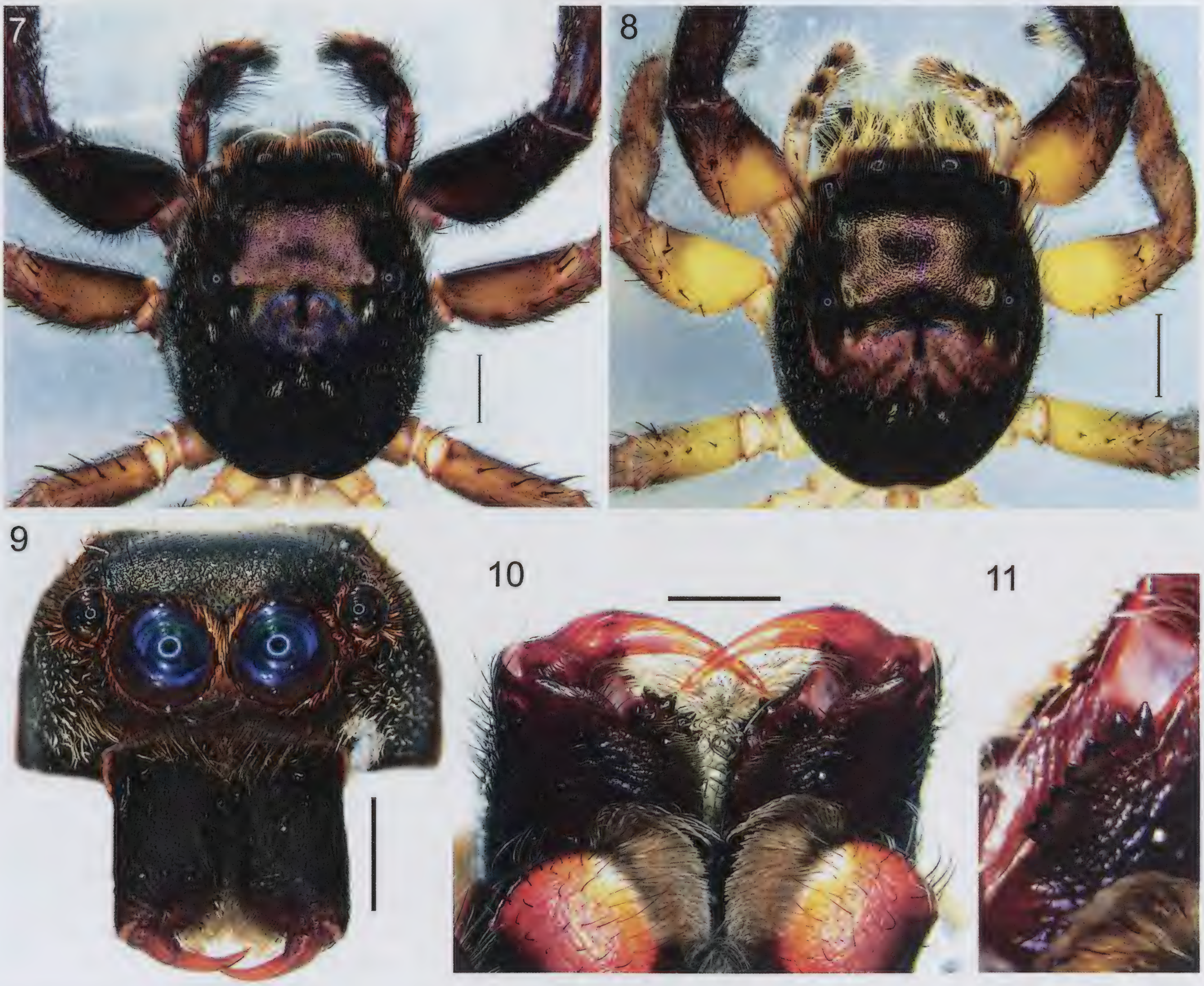
Bavia (embolus shorter than length of tegulum in *Bavia*). The male palp has a freely articulating, long embolus arising from the basal side of the tegulum from which it is clearly separated (embolus short, arising from distal prolateral corner of bulbus in *Bavia*; embolus length variable, longer emboli arising as an extension of the tegulum in *Indopadilla*). The male maxillae have a pointed retrolateral-distal corner (thumb-like in *Bavia*; rounded in *Indopadilla*). The ECP is either unpaired and central, or split into two pockets on each side of the epigynal orifice (ECP on prominent medial bulge in *Bavia*; medial in *Indopadilla*). The epigynal atrium is long and gaping, situated in an anterior position; the spermathecae are situated posterior to the copulatory openings (spermathecae placed anterior to copulatory openings in *Indopadilla*) (Maddison *et al*., 2020).

***Maripanthus gloria* Caleb, sp. nov.**
Figs 1-21

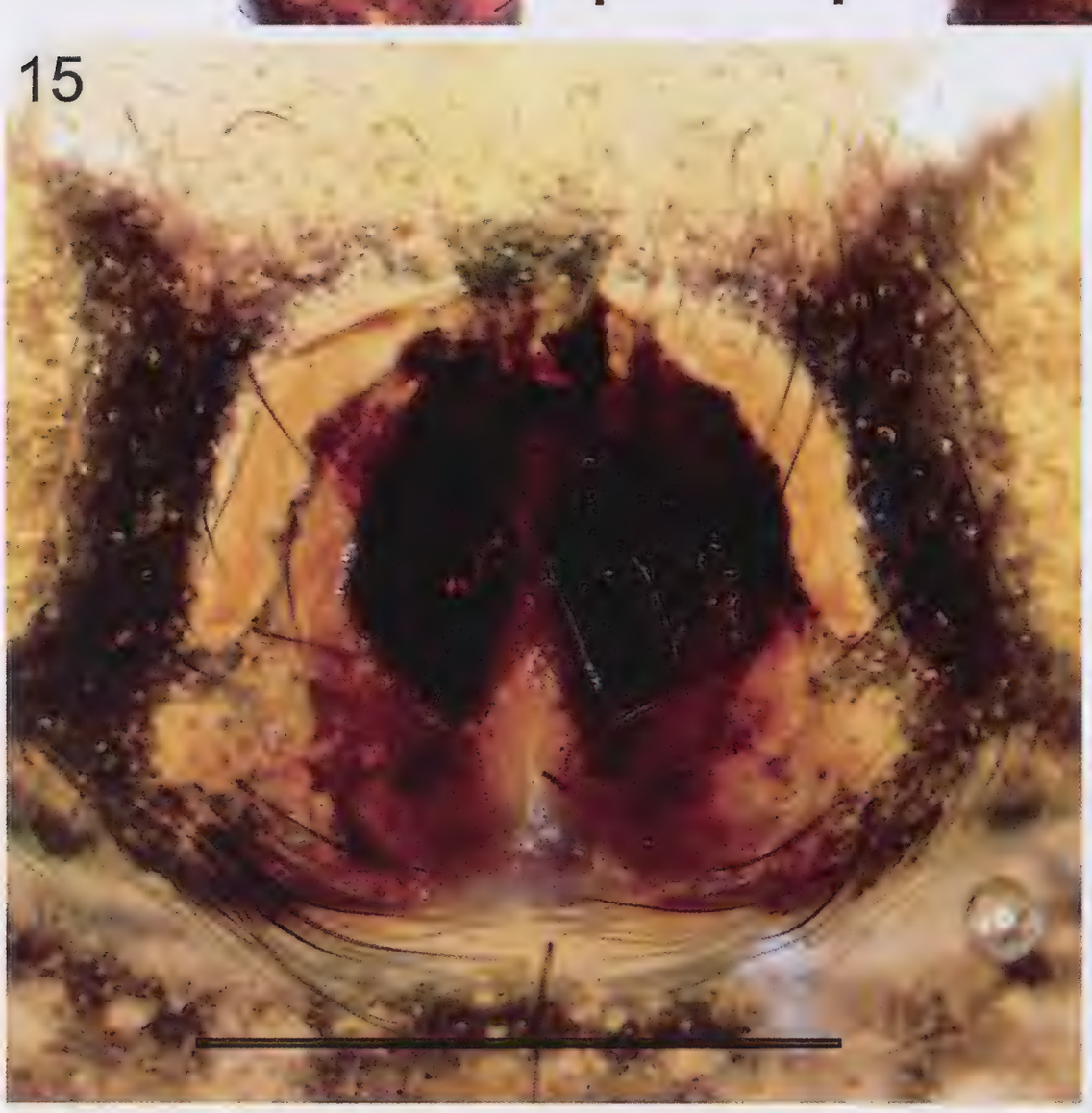
Type material: ZSIC-I/SP 36; male holotype; India, Karnataka, Bengaluru, Chelekere Lake; 13.025689°N, 77.644119°E; 887 m a.s.l.; 08.10.2020; leg. C.M. Francis & V.K. Bhat. – NCBS-IBC-BN633 & 634; 2 female paratypes, collected together with the holotype.

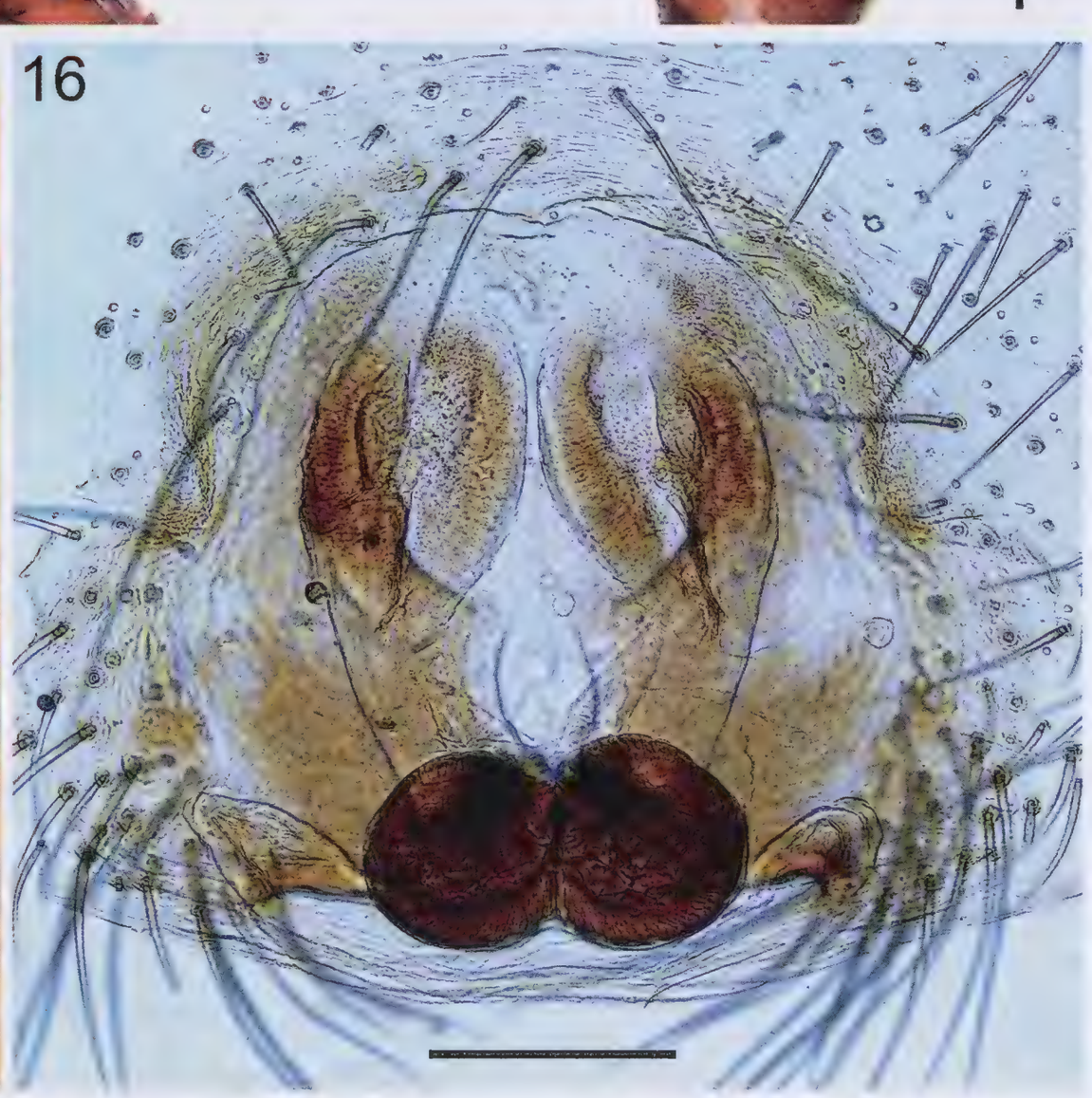
Etymology: The species is dedicated to Gloria, the daughter of the second author, for her great enthusiasm and interest during field work. The species epithet is a name in apposition.

Diagnosis: Males of the new species are similar to those of *Maripanthus draconis*, but its palp has the shortest embolus among all known congeneric males; the RTA has a broad base (Figs 12-14, 17-18 cf. Maddison *et al*., 2020: figs 188-190). Females are similar to those of *M. jubatus* by also possessing a pair of posterior

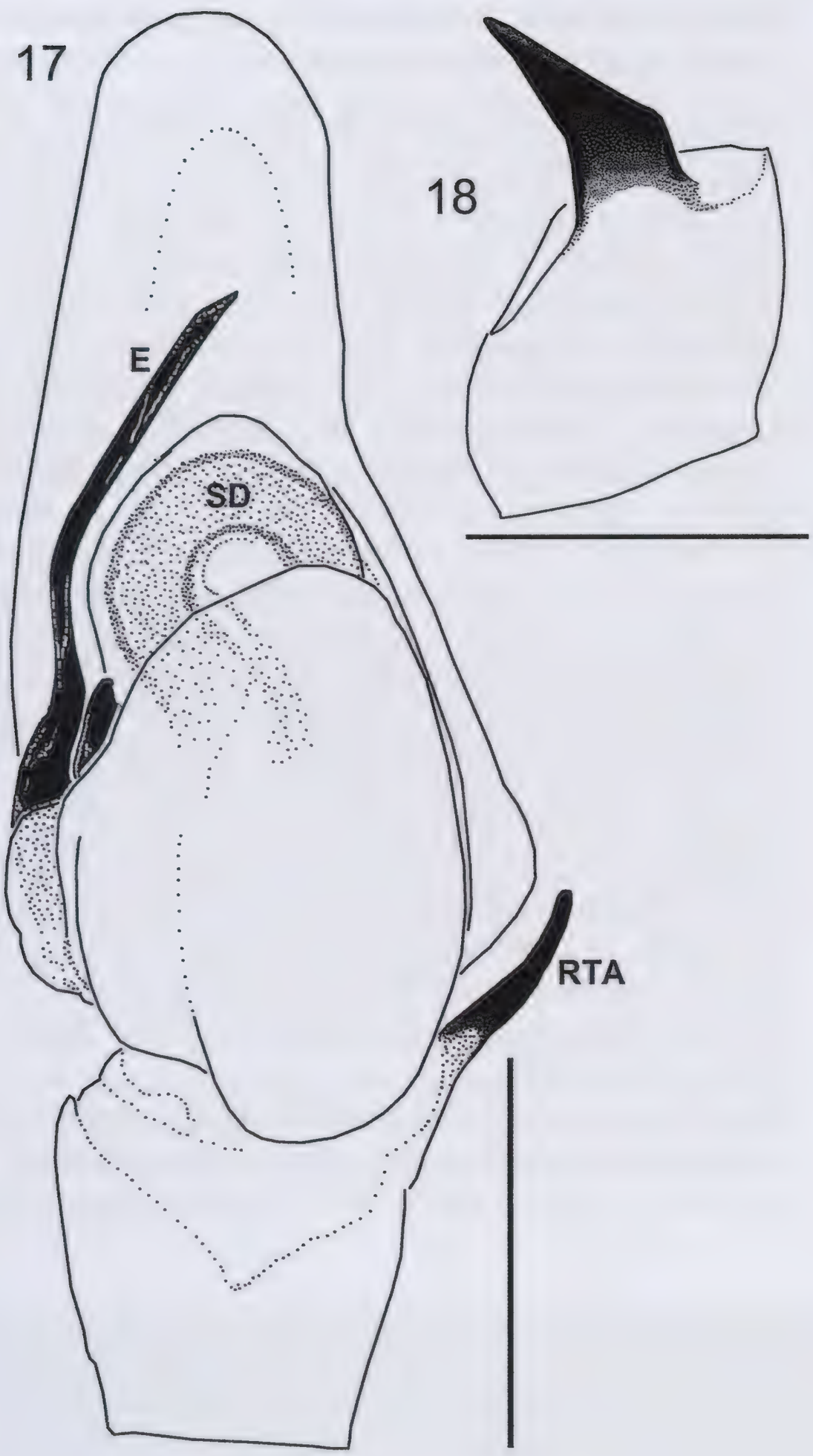


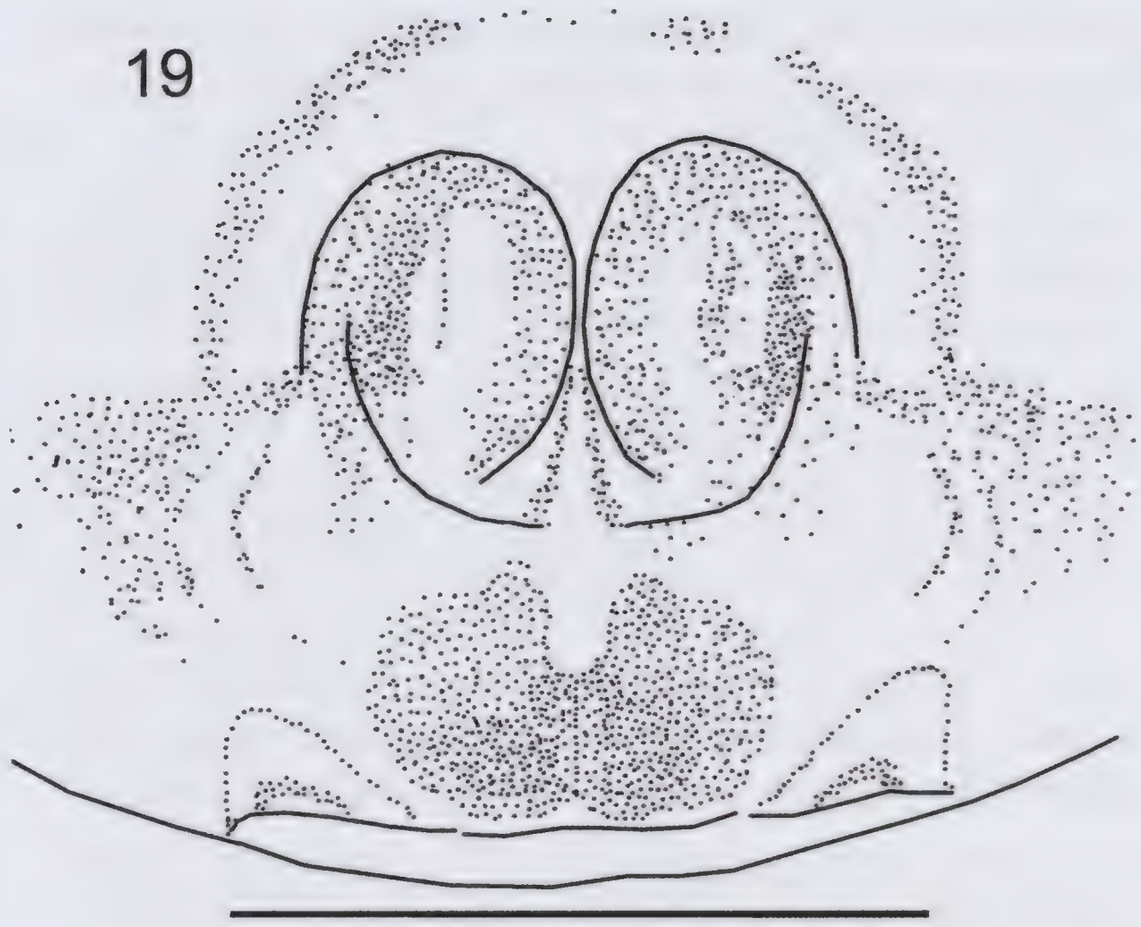
Figs 7-11. Male holotype (7, 9-11) and female paratype (IBC-BN633) (8) of *Maripanthus gloria* Caleb, sp. nov. (7-8) Carapace, dorsal view. (9) Carapace and chelicerae, frontal view. (10) Chelicerae, ventral view. (11) Retromarginal teeth of left chelicera in detail. Scale lines: 1 mm (7-9); 0.5 mm (10); not to scale (11).

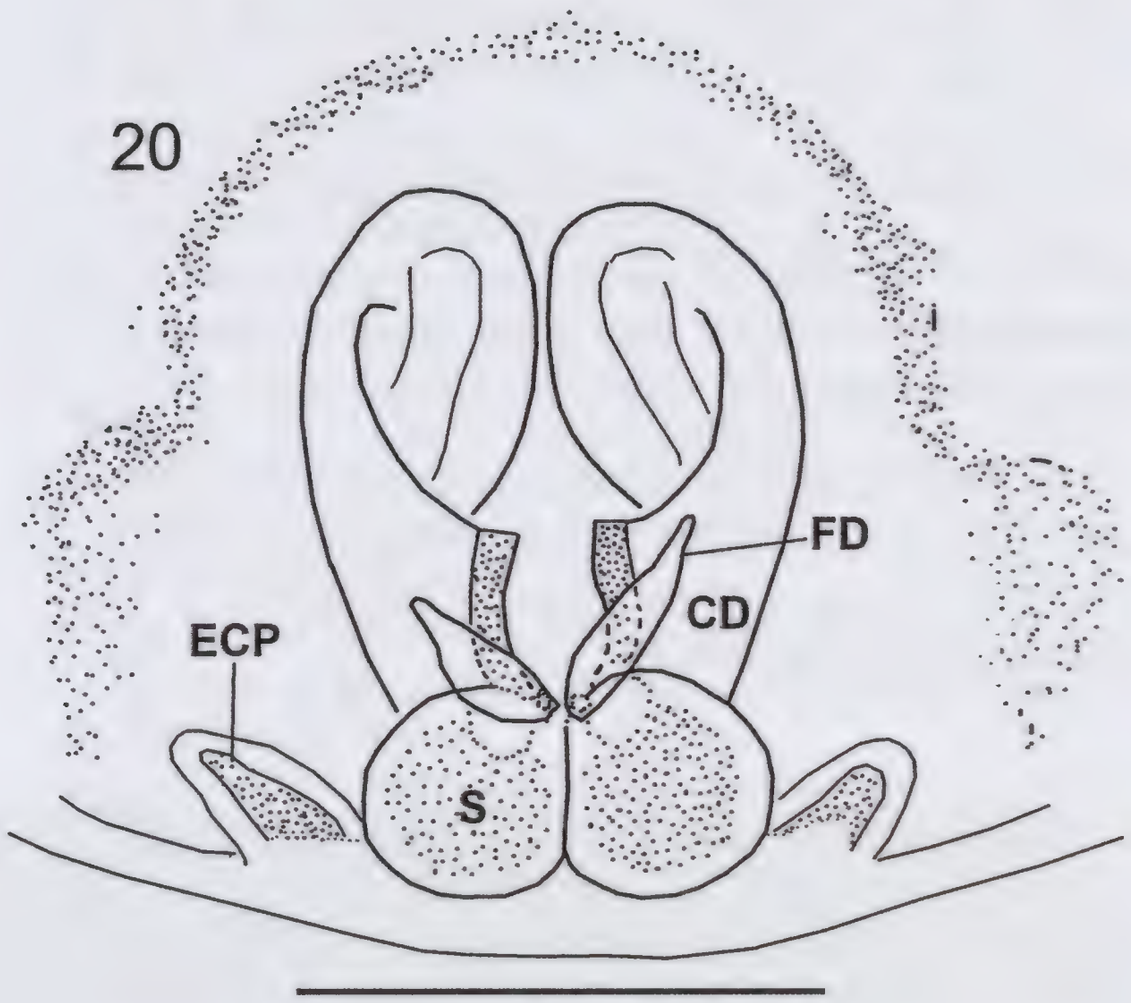




Figs 12-16. Genital morphology of *Maripanthus gloria* Caleb, sp. nov. (12) Left palp of male holotype, prolateral view. (13) Same, ventral view. (14) Same, retrolateral view. (15) Epigyne of female paratype (IBC-BN633) with mating plug, ventral view. (16) Vulva of same specimen, dorsal view. Scale lines: 0.5 mm (12-15); 0.2 mm (16).







Figs 17-20. Genital morphology of *Maripanthus gloria* Caleb, sp. nov. (17) Left palp of male holotype, ventral view. (18) Left palpal tibia of holotype, retrolateral view. (19) Epigyne of paratype (IBC-BN633), ventral view. (20) Vulva of same female, dorsal view. Abbreviations: E = embolus; CD = copulatory duct; ECP = epigynal coupling pocket; FD = fertilization duct; RTA = retrolateral tibial apophysis; S = spermatheca; SD = sperm duct. Scale lines: 0.5 mm (17-19); 0.4 mm (20).

epigynal pockets, but they differ in having short, simple insemination ducts and globular spermathecae (Figs 15-16, 19-20 cf. Maddison *et al*., 2020: figs 205-206).

Description

Male holotype: Total length 10.13; carapace 4.69 long, 3.92 wide; abdomen 5.44 long, 2.52 wide. Carapace black, covered with few scattered white scales on dorsal side of thoracic portion and on lateral sides (Figs 1, 3, 7). Clypeal region black, with brown hairs; eyes surrounded by reddish orange-coloured orbital setae (Figs 2, 9). Eye measurements: AME 0.94, ALE 0.50, PME 0.10, PLE 0.48, AER 3.01, PER 3.04, EFL 1.98. Clypeus height 0.13. Chelicerae black; three teeth on promargin and seven teeth on retromargin of fang groove (Figs 10-11). Sternum oval, yellow, with brown margin; labium and palpal coxae brown, with paler margins. Leg I robust, dark brown except for yellow tarsus; legs I-II with dense ventral fringe of hairs (Figs 2-3); legs II-IV brown, with yellow tarsi and metatarsi. Leg measurements: I 14.29 (3.91, 2.62, 3.67, 2.84, 1.25); II 9.75 (3.00, 1.85, 2.08, 1.90, 0.92); III 9.15 (2.96, 1.61, 1.49, 2.23, 0.86); IV 10.76 (3.33, 1.59, 2.36, 2.35, 1.13). Leg formula: 1423. Abdomen narrowing posteriorly; brownish, lighter medially; covered with black hairs (Figs 1, 3). Venter light brown, with a broad dark brown median region. Spinnerets brown. Palps dark brown; cymbium dorsally clothed with yellowish white hairs, with a dense fringe of black hairs prolaterally (Figs 2, 12-14); embolus thick,

needle-like, arising from prolateral base of bulbus; RTA blade-like, with a broad base and pointed tip, directed ventrad (Figs 13-14, 18).

Female paratype (IBC-BN633): Total length 9.82, carapace 3.85 long, 3.29 wide; abdomen 5.97 long, 3.13 wide. Eye measurements: AME 0.86, ALE 0.40, PME 0.09, PLE 0.42. AER 2.54, PER 2.61, EFL 1.82. Clypeus height 0.15. Leg measurements: I 8.15 (2.42, 1.71, 1.88, 1.46, 0.68); II 6.85 (2.15, 1.42, 1.40, 1.25, 0.63); III 6.82 (2.21, 1.22, 1.11, 1.58, 0.70); IV 8.26 (2.56, 1.16, 1.82, 2.03, 0.69). Leg formula: 4123. Colouration pattern mostly as in male (Figs 4-6), different in the following: clypeus covered with yellowish hairs (Fig. 5); legs with paler proximal part of femora; legs III-IV with dark annulations close to joints (Figs 4, 6). Palps yellow, with dark brown annulations proximally (Fig. 5). Epigyne with a pair of shallow depressions separated by a raised septum in anterior half; a pair of pockets present at posterior epigynal margin; insemination ducts short, broad; spermathecae globular and contiguous with each other (Figs 15-16, 19-20).

Distribution: Known only from the type locality in India (Karnataka) (Fig. 21).

Note: Both paratype females examined have their epigynal region covered with a mating plug (Fig. 15). The presence of mating plugs in this genus is here recorded for the first time.

Habitat: The new species was collected from a public park in which lies the Chelekere Lake.

Discussion: When Maddison (2015) provided the first phylogenetic classification of the Salticidae only three genera were included in the tribe Baviini Simon, 1901a. In the most recent updated review (Maddison *et al*., 2020) it includes seven genera (*Bavia*, *Indopadilla*, *Maripanthus*, *Padillothorax* Simon, 1901b, *Padillothorus* Prószyński, 2018 [assigned tentatively], *Piranthus* Thorell, 1895, and *Stagetillus* Simon, 1885). In India the tribe was known from a single species, *Padillothorax casteti* (Simon, 1900), until another species, *Bavia insularis* Malamel, Sankaran & Sebastian, 2015 (presently *Indopadilla insularis*), was described (see Malamel, Sankaran & Sebastian, 2015). More studies in the past four years have increased our knowledge of this group considerably (Caleb & Sanap, 2017; Malamel *et al*., 2019; Caleb *et al*., 2019; Nafin *et al*., 2020; Maddison *et al*., 2020). Of the 275 species of Salticidae currently known from India, seven species (2.5%) belong to the Baviini (*Indopadilla* - 3 species, *Piranthus* - 2 species, and one each of *Padillothorax* and *Maripanthus)* (see Caleb & Sankaran, 2021). The present paper adds the description of another species from southern India.

Some members of *Bavia* and *Indopadilla* superficially resemble those of *Maripanthus*, and confusion in generic placement of species among these three genera can occur.

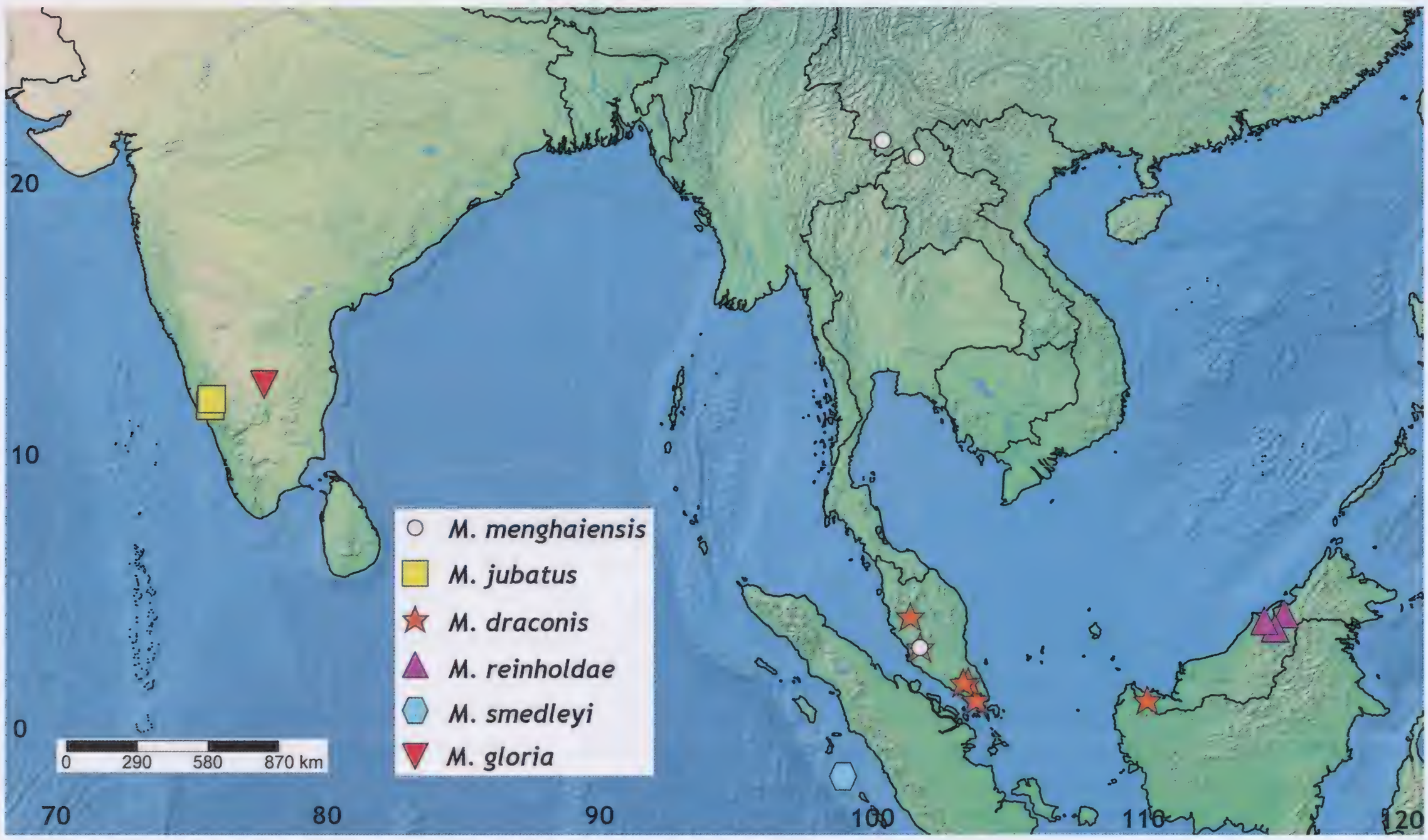


Fig. 21. Distributional records of all known *Maripanthus* species.

We place the new species confidently in *Maripanthus* on the basis of the following characters: chelicerae without the characteristic ridge and the thorax without bulges as seen in *Indopadilla* (Figs 1, 4, 7-9); embolus free, arising on the prolateral side of the bulbus, separated from the tegulum (Figs 12-13, 17), unlike in *Bavia* and *Indopadilla*; ECP split into pockets on each side of the epigynal orifice as in *M. jubatus,* but unlike in *Bavia* and *Indopadilla* which have an unpaired medial ECP; epigynal atria gaping (Figs 16, 19-20) (see Maddison *et al*., 2020). This leaves no doubt that the new species is a member of *Maripanthus,* not of *Bavia* or *Indopadilla*.

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REFERENCES

Caleb J.T.D., Sanap R.V. 2017. Rediscovery of *Piranthus decorus* Thorell 1895 (Araneae: Salticidae) after 122 years since the original description. *Acta Arachnologica* 66(1): 25-29.

Caleb J.T.D., Sankaran P.M. 2021. Araneae of India. Version 2021. Available from: http://www.indianspiders.in (accessed 27 January 2021).

Caleb J.T.D., Sankaran P.M., Nafin K.S., Acharya S. 2019. *Indopadilla*, a new jumping spider genus from India (Araneae: Salticidae). *Arthropoda Selecta* 28(4): 567-574.

Cao Q., Li S.Q., Żabka M. 2016. The jumping spiders from Xishuangbanna, Yunnan, China (Araneae, Salticidae). *ZooKeys* 630: 43-104.

Maddison W.P. 2015. A phylogenetic classification of jumping spiders (Araneae: Salticidae). *Journal of Arachnology* 43: 231-292.

Maddison W.P., Beattie I., Marathe K., Ng P.Y.C., Kanesharatnam N., Benjamin S.P., Kunte K. 2020. A phylogenetic and taxonomic review of baviine jumping spiders (Araneae: Salticidae: Baviini). *Zookeys* 1004: 27-97.

Malamel J.J., Sankaran P.M., Sebastian, P.A. 2015. First record of the jumping spider genus *Bavia* Simon, 1877 from India, with the description of a new species. *Zootaxa* 4007(4): 596-599.

Malamel J.J., Nafin K.S., Sudhikumar A.V., Sebastian P.A. 2019. Two new species of the jumping spiders (Araneae: Salticidae) from the genera *Epeus* Peckham et Peckham, 1886 and *Piranthus* Thorell, 1895 from India. *Arthropoda Selecta* 28(2): 267-276.

Nafin K.S., Maddison W.P., Sudhikumar A.V. 2020. The first described male of the Asian jumping spider genus *Piranthus* Thorell, 1895 (Araneae: Salticidae: Baviini). *Peckhamia* 207.1: 1-7.

Prószyński J. 2018. Review of genera *Evarcha* and *Nigorella*, with comments on *Emertonius*, *Padilothorax* [sic], *Stagetillus*, and description of five new genera and two new species (Araneae: Salticidae). *Ecologica Montenegrina* 16: 130-179.

Reimoser E. 1929. Spolia Mentaweiensia. Araneae. *Bulletin of the Raffles Museum Singapore* 2: 125-133.

Shorthouse D.P. 2010. SimpleMappr, an online tool to produce publication-quality point maps. Available from: http://www.simplemappr.net (accessed 21 December 2020).

Simon E. 1877. Etudes arachnologiques. 5e Mémoire. IX. Arachnides recueillis aux îles Phillipines par MM. G. A. Baer et Laglaise. *Annales de la Société Entomologique de France* (5) 7: 53-96.

Simon E. 1885. Arachnides recueillis par M. Weyers à Sumatra. Premier envoi. *Annales de la Société Entomologique de Belgique* 29: 30-39.

Simon E. 1900. Descriptions d'arachnides nouveaux de la famille des Attidae. *Annales de la Société Entomologique de Belgique* 44: 381-407.

Simon E. 1901a. Histoire naturelle des araignées. Deuxième édition, tome second. *Roret, Paris*, pp. 381-668.

Simon E. 1901b. On the Arachnida collected during the Skeat expedition to the Malay Peninsula. *Proceedings of the Zoological Society of London* 71(1): 45-84.

Thorell T. 1895. Descriptive catalogue of the spiders of Burma, based upon the collection made by Eugene W. Oates and preserved in the British Museum. *Taylor & Francis, London*, 406 pp.

World Spider Catalog 2021. World Spider Catalog. Version 22.0. Natural History Museum Bern. Available from: http://wsc.nmbe.ch (accessed 27 January 2021).

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A new species of *Vietnamophryne* from Vietnam

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Abstract: A new species of the genus *Vietnamophryne* is described from Vu Quang National Park in North Vietnam based on molecular phylogenetic and morphological analyses. The new species is morphologically distinct from congeners and can be easily distinguished from all other members of the genus *Vietnamophryne* by (1) body size males (n=4) 14.12-14.91 mm; females (n=9) 15.15-17.33 mm; (2) dorsal skin shagreened with small flat pustules loosely scattered on back in males, mostly smooth, slightly shagreened posteriorly, lacking enlarged tubercles in females; (3) belly color ivory-lemon to lemon-yellow with weak dark-brown marbling in males, bright lemon-yellow with weak dark-brown marbling in females; (4) tympanum relatively faint, comparatively small, rounded, 5.4-6.0% of SVL in males, 4.8-6.2% of SVL in females; (5) ratio snout length to eye length 119-128% in males, 100-130 % in females; (6) ratio head width to head length 117-124% in males, 110-131% in females; and (7) ratio first finger to second finger 43-49% in males, 44-50% in females. In the phylogenetic analysis the new species revealed to be sister to *V. inexpectata*, with 4.3-4.6% divergence in the 16SrRNA gene. So far, the new species is only known from the evergreen tropical forests of Vu Quang National Park at an elevation of 966 m a.s.l. This is the third species of *Vietnamophryne* reported from Vietnam.

Keywords: *Vietnamophryne vuquangensis* **sp. nov.** - MtDNA phylogeny - New species - Taxonomy - Vietnam.

INTRODUCTION

The genus *Vietnamophryne* Poyarkov, Suwannapoom, Pawangkhanant, Aksornneam, Duong, Korost & Che, 2018 was only recently erected. It belongs to the subfamily *Asterophryinae* and is sister taxon to *Siamophryne*. *Vietnamophryne* consists of three species of small-sized frogs reportedly occurring at two localities in Vietnam (*V. inexpectata* from a primary montane tropical forest in Kon Chu Rang, Nature Reserve (NR) Gia Lai Province and *V. orlovi* from a primary montane subtropical forest on the southern slopes of Phia Oac Mt., Phia Oac-Phia Den National Park (NP), Cao Bang Province) and at one locality in northern Thailand (*V. occidentalis* from a primary montane subtropical forest on limestone outcrops of Doi Tung Mt., Pong Ngam District, Chiang Rai Province) (Frost, 2020; Poyarkov *et al.,* 2018).

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During recent field research in North Central Vietnam, a series of Indochinese Dwarf Frogs were collected from Vu Quang National Park (NP), in Ha Tinh Province, Vietnam. Based on morphological differences and molecular divergence, we herein describe this population as a distinct *Vietnamophryne* species.

MATERIAL AND METHODS

Sampling: Field surveys were conducted in Vu Quang NP, Ha Tinh Province, Vietnam (Fig. 1) on 12 October 2019 by T. T. Nguyen, Q. H. Nguyen and N. Orlov. Geographic coordinates and elevation were obtained using a Garmin GPSMAP 78S (WGS 84 data). Thirteen specimens (n = 9, females VNMN 010487, 010491, 010492, 010517-010521, 010528; n = 4, males VNMN 010488-010490, 010498) were collected in the field. After photographing animals in life, specimens were euthanized in a closed vessel with a piece of cotton wool containing ethyl acetate, fixed in 95% ethanol for 8-10 hours and subsequently stored in 70% ethanol (Simmons, 2002). Tissues for genetic analyses were taken from liver prior to preservation and stored in 95% ethanol. Specimens were subsequently deposited in the Vietnam National Museum of Nature (VNMN) Hanoi, Vietnam.

Molecular analyses

DNA extraction and sequencing

Extraction of genomic DNA from 13 tissue samples (Table 1) was carried out using TIANamp Genomic DNA kit (TIANGEN BIOTECH, Beijing, China), Tiangen following the manufacturer's instructions. Total DNA was amplified using an Eppendorf PCR machine. PCR total volume was 25 µl, consisting of 12 µl of Mastermix, 6 µl of water, 1 µl of each primer at a concentration of 10 pmol/µl, and 5 µl of DNA. Primers used in the PCR and sequencing were as follows: 12SAL (5'-AAACTGGGATTAGATACCCCACTAT-3'; forward), 16S2000H (5'-GTGATTAYGCTACCTTTGC-ACGGT-3'; reverse) (Zhang *et al.*, 2008) and LR-N-13398 (5'-CGCCTGTTTACCAAAAACAT -3'; forward), LR-J 12887 (5'-CCGGTCTGAACTCAGATCACGT -3'; reverse) (Simon, 1994). PCR conditions: 94°C for 5 minutes of initial denaturation; with 35 cycles of denaturation at 94°C for 30 s, annealing at 56°C for 30 s, and extension at 72°C for 45 s; and the final extension at 72°C for 7 minutes. PCR products were sent to Tsingke Biological Technology company for sequencing (http://www.tsingke.net). The obtained sequences were deposited in GenBank under the accession numbers MW763017 to MW763029 (Table 1). We amplified a 1940 base pair (bp) length fragment of the 12S rRNA–

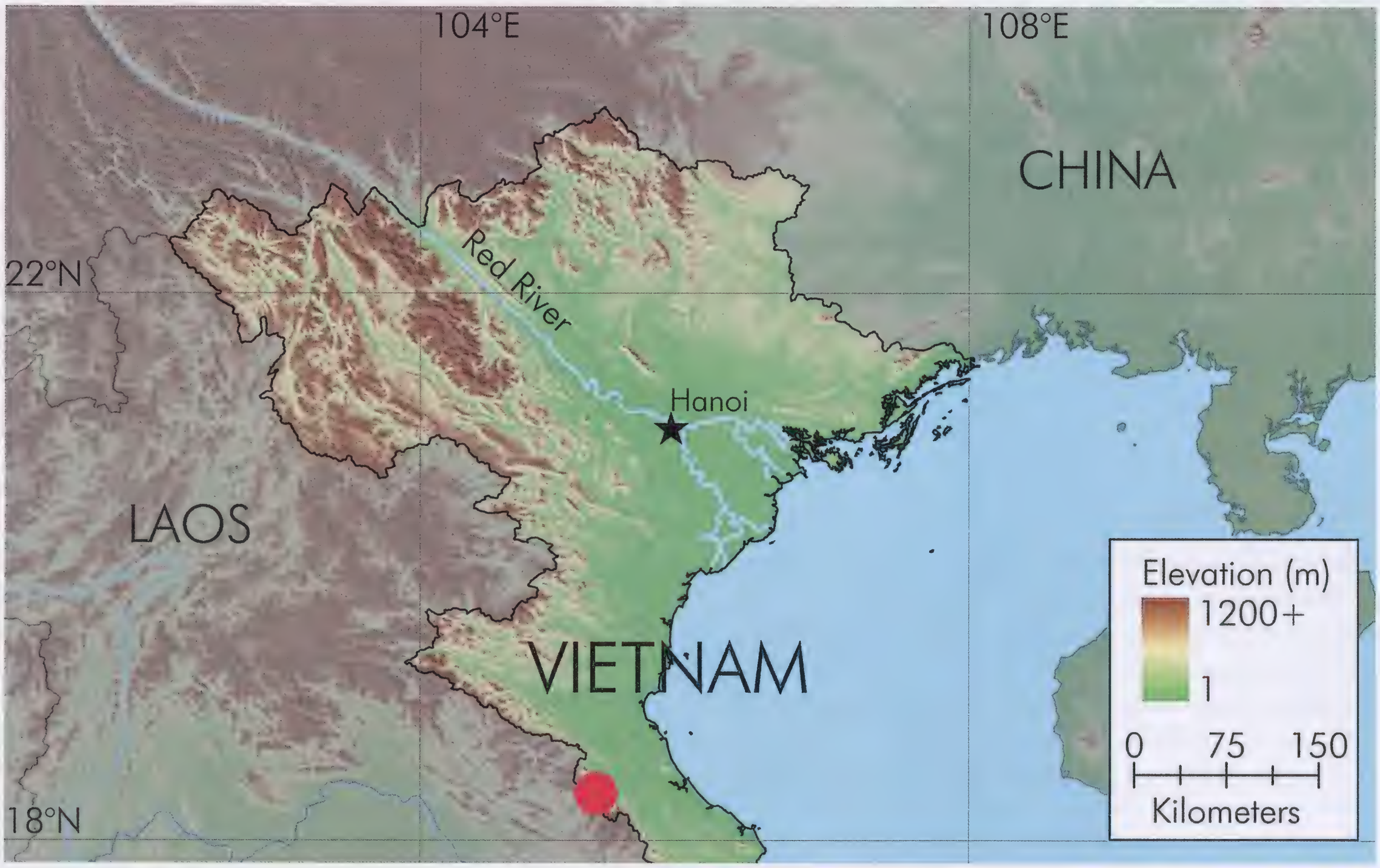

Fig. 1. Map showing the type locality of *Vietnamophryne vuquangensis* **sp. nov.** (red circle) in Vu Quang NP, Ha Tinh Province, Vietnam.

Table 1. GenBank accession numbers, and associated samples that were used in this study. All sequences generated by this study have accession numbers: MW73017-MW763029.

No.	Species	Locality	Voucher	Accession No.	Reference
1.	*Vietnamophryne vuquangensis* **sp. nov.**	Vu Quang NP, Ha Tinh Province, Vietnam	VNMN 010487 VNMN 010488 VNMN 010489 VNMN 010490 VNMN 010491 VNMN 010492 VNMN 010498 VNMN 010517 VNMN 010518 VNMN 010519 VNMN 010520 VNMN 010521 VNMN 010528	MW763017 MW763018 MW763019 MW763020 MW763021 MW763022 MW763023 MW763024 MW763025 MW763026 MW763027 MW763028 MW763029	This study
2.	*V. inexpectata*	Kon Chu Rang NR, Gia Lai Province, Vietnam	ZMMU A-5820	MH004403	Poyarkov *et al.* (2018)
3.	*V. occidentalis*	Doi Tung Mt., Chiang Rai, Thailand	ZMMU A-5822	MH004406	Poyarkov *et al.* (2018)
4.	*V. orlovi*	Phia Oac-Phia Den NP, Cao Bang Province, Vietnam	ZMMU A-5821	MH004404	Poyarkov *et al.* (2018)
	Outgroup				
5.	*Siamophryne troglodytes*	Sai Yok, Kanchanaburi, Thailand.	ZMMU NAP-06651	MG682553	Suwannapoom *et al.* (2018)

16S rRNA mitochondrial gene (457bp of 12S ribosomal RNA, 68bp of tRNA-Val, 1415bp of 16S ribosomal RNA).

Phylogenetic analysis

In addition to the newly collected series, all specimens belonging to the genus *Vietnamophryne* for which homologous sequences were available (in this publication for all 3 *Vietnamophryne* species) were included in the phylogenetic analysis. *Siamophryne troglodytes* was included in the analysis as an outgroup. Locality information and accession numbers for all sequences included in the analysis are shown in Table 1. Chromas Pro software (Technelysium Pty Ltd., Tewantin, Australia) was used to edit the sequences, which were aligned using the ClustalW (Thompson *et al.,* 1997) option in MEGA 7.0 (Kumar *et al.,* 2016) with default parameters and subsequently optimized manually in BioEdit 7.0.5.2 (Hall, 1999). We then checked the initial alignments by eye and adjusted slightly to exclude some positions of 12S rRNA and tRNA-Val. Only fragments of the 16S rRNA (707bp) gene were used for phylogenetic tree analysis. Phylogenetic trees were constructed by using maximum likelihood (ML) and Bayesian inference (BI). Prior to ML and Bayesian analyses, we chose the optimum substitution models for entire sequences using by Kakusan 4 (Tanabe, 2011) based on the Akaike information criterion (AIC). The BI summarized two independent runs of four Markov Chains for 10 000 000 generations. A tree was sampled every 100 generations and a consensus topology was calculated for 70 000 trees after discarding the first 30 001 trees [burnin = 30 0010 (Nguyen *et al.,* 2014)]. We checked parameter estimations and convergence using Tracer version 1.7.1 (Rambaut *et al.,* 2018). The strength of nodal support in the ML tree was analyzed using non-parametric bootstrapping (MLBS) with 1000 replicates. We regarded tree nodes in the ML tree with bootstrap values of 75% or greater as sufficiently resolved (Hillis & Bull, 1993; Huelsenbeck & Hillis, 1993), and nodes with a BPP of 95% or greater as significant in the BI analysis (Leaché & Reeder, 2002).

Morphological analysis

Sex of adult individuals was determined using gonadal dissection. All measurements were taken from fixed specimens using a digital caliper to the nearest 0.01 mm and subsequently rounded to a 0.1 mm precision; morphometrics followed Poyarkov *et al.* (2014), Suwannapoom *et al.* (2018) and Poyarkov *et al.* (2018): (1) snout-vent length (SVL; length from tip of snout to cloaca); (2) head length (HL; length from tip of snout to rear of jaw angle); (3) snout length (SL; length from anterior corner of eye to tip of snout); (4) eye length (EL; distance between anterior and posterior corners of eye); (5) nostril-eye length (N-EL; distance between anterior corner of eye and nostril center); (6) head width (HW;

maximum width of head at level of mouth angles in ventral view); (7) internarial distance (IND; distance between central points of nostrils); (8) interorbital distance (IOD; shortest distance between eyeballs in dorsal view); (9) upper eyelid width (UEW; maximum distance between eyeball and lateral edge of upper eyelid); (10) forelimb length (FLL; length of straightened forelimb from limb base to tip of third finger); (11) lower arm and hand length (LAL; distance between elbow and tip of third finger); (12) hand length (HAL; distance between proximal end of outer palmar (metacarpal) tubercle and tip of third finger); (13) inner palmar tubercle length (IPTL; maximum distance between proximal and distal ends of inner palmar tubercle); (14) outer palmar tubercle length (OPTL; maximum diameter of outer palmar tubercle); (15) hindlimb length (HLL; length of straightened hindlimb from groin to tip of fourth toe); (16) tibia length (TL; distance between knee and tibiotarsal articulation); (17) foot and tibiotarsus length (FTL; length from tibiotarsal joint to end of fourth toe); (18) foot length (FL; distance between distal end of tibia and tip of fourth toe); (19) inner metatarsal tubercle length (IMTL; maximum length of inner metatarsal tubercle); (20) outer metatarsal tubercle length (OMTL; maximum length of outer metatarsal tubercle); (21) tympanum length, maximum tympanum diameter (TYD); (22) tympanum-eye distance (TED); (23-26) finger lengths (1-3FLO, 4FLI; for outer side (O) of first, inner side (I) of fourth, distance between tip and junction of neighboring finger); (27) first finger width (1FW), measured at distal phalanx; (28-30) finger disk diameters (2-4FDW); (31) first toe length (1TOEL), distance between distal end of inner metatarsal tubercle and tip of first toe; (32-35) second to fifth toe lengths (outer lengths for toes II-IV, inner length for toe V); (36-40) toe disk diameters (1-5TDW).

We obtained comparative morphological data from the original descriptions of species of *Vietnamophryne*: *V. inexpectata* Poyarkov, Suwannapoom, Pawangkhanant, Aksornneam, Duong, Korost & Che, 2018; *V. occidentalis* Poyarkov, Suwannapoom, Pawangkhanant, Aksornneam, Duong, Korost & Che, 2018; *V. orlovi* Poyarkov, Suwannapoom, Pawangkhanant, Aksornneam, Duong, Korost & Che, 2018.

RESULTS

Sequence variation

Results of the phylogenetic analyses are shown in Fig. 2. The 16S rRNA gene fragments consisted of 707 sites: 650 sites were conserved and 57 sites were variable, of which 35 were parsimony-informative. The transition–transversion bias was estimated as 6.098. Nucleotide frequencies were A=34.09%, T=23.10%, C=24.45%, and G=18.36%. The Bayesian and Maximum likelihood analyses produced topologies with –ln L = 1581.393 and 1463.9769, respectively. The best model selected for BI was the general time reversible model (GTR: Tavaré, 1986) with a gamma shape parameter (G: 0.418 in BI; 0.282in ML).

Phylogenetic analyses employing BI methods, with most well-supported nodes on the Bayesian tree are presented in Fig. 2. In the analyses, the newly collected *Vietnamophryne* specimens were recovered as sister to *V. inexpectata*, which was recently described from southern Vietnam (Poyarkov *et al.,* 2018).

Interspecific uncorrected p-distances of the *Vietnamophryne* (Table 2) ranged from 1.9% (between *V. orlovi* and *V. occidentalis*) to 6.2% (between the new form and *V. orlovi*). The genetic divergence of the new form from Vu Quang NP and its congeners ranged from 4.3-4.6% (*V. inexpectata*) to 5.8-6.2% (*V. orlovi*), which was distinctly higher than genetic distances between *V. orlovi* and *V. occidentalis* (1.9%), and distances between *V. occidentalis* and *V. inexpectata* (4%). Individuals in populations of the new form have genetic differences from 0.01% to 0.03%. This is indicating that the differentiation between the new form and other species of *Vietnamophryne* has reached specific level, which was supported by morphological distinctiveness.

Vietnamophryne vuquangensis sp. nov.

Figs 3-4; Table 3

Holotype: VNMN 010489, adult male, collected in evergreen tropical forest at Vu Quang National Park, Ha Tinh Province, Vietnam (18°15’47.9”N 105°20’25.1”E at an elevation of 966 m a.s.l.) on 12 October 2019 by T. T. Nguyen and Q. H. Nguyen.

Paratypes (n=12): Three adult males (VNMN 010488, VNMN 010490, VNMN 010498), nine adult females (VNMN 010487, VNMN 010491, VNMN 010492, VNMN 010517 to VNMN 010521, VNMN 010528) same location of holotype, collected on 12 October 2019 by Q. H. Nguyen from a forest (18°15’47.9”N 105°20’25.1”E at an elevation of 966 m a.s.l.)

Diagnosis: (1) Body size small SVL (n=4 males, 14.12-14.91 mm; n=9 female, 15.15-17.33 mm); (2) body habitus stout FLL/SVL and HLL/SVL ratios 52-55% and 149-157% in males; 50-58% and 136-158% in females, respectively; (3) Head length greater than width, HW/HL ratio 117-124% in males, 110-131% in females; (4) snout comparatively long, rounded in dorsal view, snout length greater than eye length (SL/EL ratio 119-128% in males; 103-130% in females); (5) eye medium-sized, eye length/snout-vent length ratio 11% in males; 10-12% in females; eye to nostril distance 6-7% of SVL; (6) tympanum relatively blurred in males, comparatively small, rounded, TYD/SVL ratio 5.4-6.0% in males, 4.8-6.2% in females; (7) first finger (F1) well developed, less than half of second finger (F2) (1FLO/2FLO ratio 43-49% in

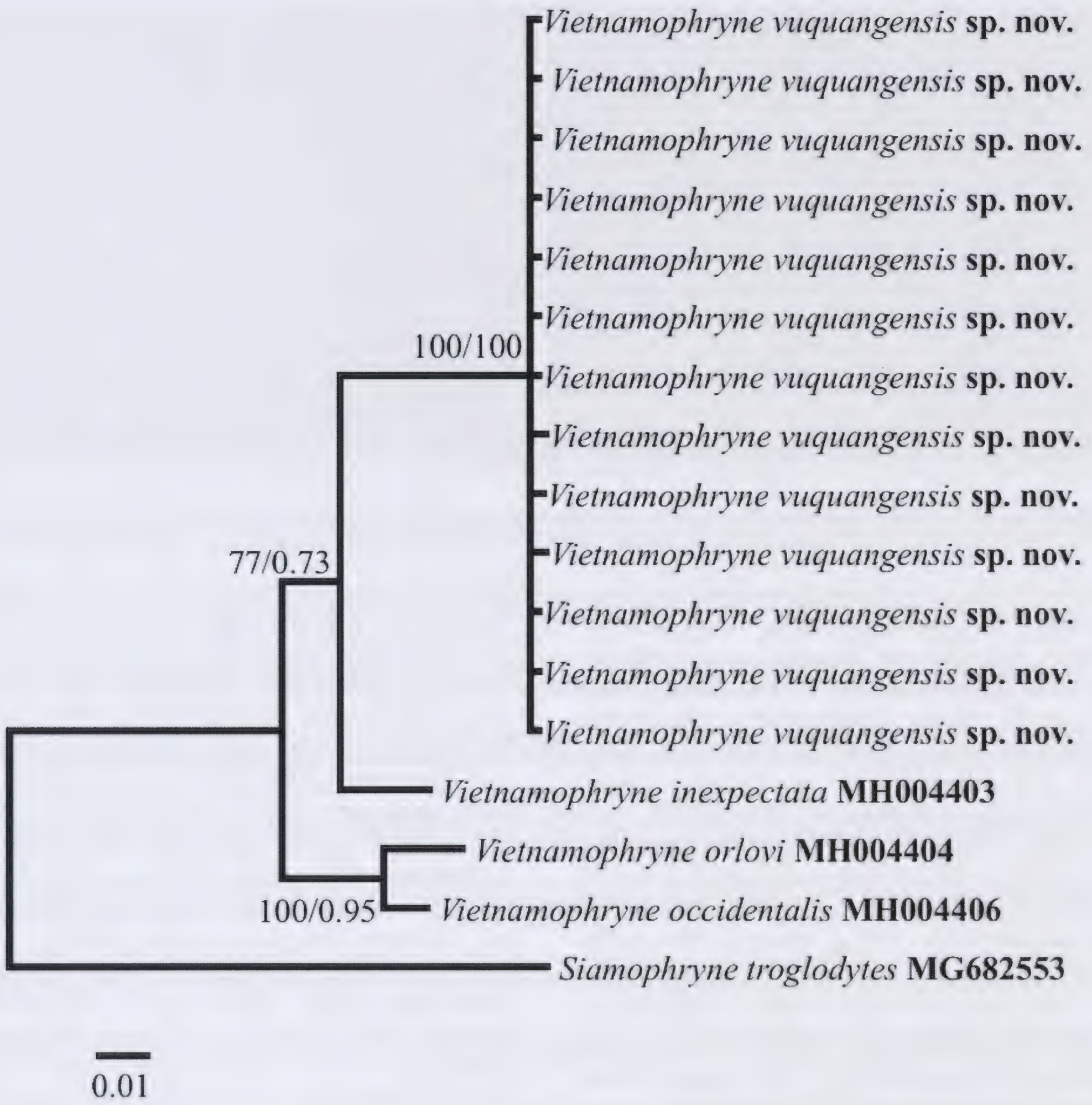

Fig. 2. Bayesian inference (BI) tree based on the partial 16S rRNA mitochondrial gene. Values at nodes correspond to BI/ML support values, respectively. Numbers above and under branches are ML bootstrap values and Bayesian posterior probabilities. *Siamophryne troglodytes* are used as the outgroup.

Table 2. Uncorrected ("p") distance matrix showing percentage pairwise genetic divergence 16S rRNA between members of the *Vietnamophryne* species group and outgroup (*Siamophryne*).

		1	2	3	4
1	*Vietnamophryne vuquangensis* **sp. nov.**	0-0.1			
2	*Vietnamophryne inexpectata*	4.3-4.6			
3	*Vietnamophryne occidentalis*	5.7-6.0	0.04		
4	*Vietnamophryne orlovi*	5.8-6.2	0.048	0.019	

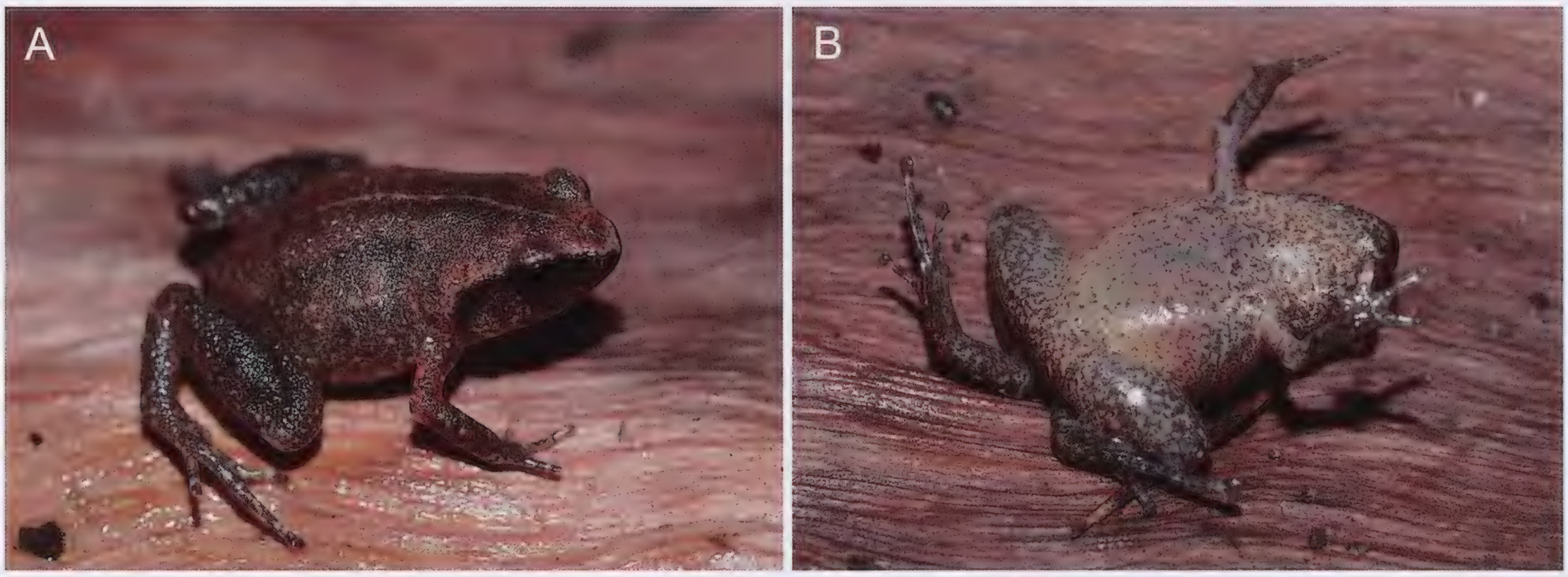

Fig. 3. Holotype (VNMN 010489, male) of *Vietnamophryne vuquangensis* **sp. nov.** in life: dorsolateral view (A) and ventral view (B).

male, 44-50% in females), relative finger lengths: I<IV<II<III, relative toe lengths: I<II<V<III<IV; (8) tips of all digits rounded, not expanded in F1-F4, T1, T2, and T5, weakly expanded in T3 and T4; (9) subarticular tubercles under fingers and toes weak, indistinct; (10) outer metatarsal tubercle absent, inner metatarsal tubercle small, flattened (3-5% of SVL); (11) skin of ventral surface completely smooth, dorsal skin shagreened with small flat pustules loosely scattered on dorsum in males, dorsal skin mostly smooth, slightly shagreened posteriorly, lacking enlarged tubercles in females; (12) belly color ivory-lemon to lemon-yellow with weak dark-brown marbling in males, bright lemon-yellow with weak dark-brown marbling in female.

Description of holotype: Body size small, habitus stout with SVL 14.91 mm an, head wider than long (HW/HL 117%), snout comparatively long, obtuse, rounded in dorsal view (Fig. 4A), truncate in lateral view (Fig. 4E), snout length greater than eye length (SL/EL ratio 128%); nostril small, rounded, lateral, much nearer to tip of snout than to eye (N-EL/EL ratio 63%); dorsal surface of head slightly convex; canthus rostralis distinct, rounded; loreal region concave; eyes medium-sized (EL/SVL ratio 11%); eye to nostril distance 7% of SVL; eyes slightly protuberant in dorsal and lateral views; pupil round; tympanum relatively faint, comparatively small, rounded, 5% of SVL; supratympanic fold present, distinct, glandular (Fig. 4E); vomerine teeth and spikes absent; tongue spatulate and free behind, papillae on tongue absent and vocal sac opening indiscernible.

Forelimbs comparatively short, around one-third of hindlimb length (FLL/HLL 35%); hand shorter than lower arm, almost one-third of forelimb length (HAL/FLL 42%); fingers short, round in cross-section, first finger well developed, almost a third of length of second finger (1FL/2FL 45%); relative finger lengths: I<IV<II<III (Fig. 4C). Finger webbing absent; dermal fringes present, weak. Tips of fingers rounded, not dilated, finger disks absent, terminal grooves absent; longitudinal furrow on dorsal surface of fingers absent; subarticular tubercles under fingers indistinct; nuptial pad absent; two palmar tubercles: inner palmar tubercle small, oval; outer palmar tubercle oval, slightly longer than inner palmar tubercle (IPTL/OPTL 78%); palmar surface smooth, supernumerary palmar tubercles absent.

Hindlimbs short and thick, tibia length less than half of snout-vent length (TL/SVL 48.0%); tibiotarsal articulation of adpressed limb reaching eye level; foot length equal to tibia length (FL/TL 99%); relative toe lengths: I<II<V<III<IV; tarsus smooth, tarsal fold absent; tips of toes rounded, tips of toes III and IV slightly dilated (Fig. 4D), terminal grooves absent; toes rounded in cross-section; toe webbing absent between all toes; dermal fringes on toes present, weak; subarticular tubercles under toes indistinct; single metatarsal tubercle: inner metatarsal tubercle rounded, flattened (IMTL/SVL ratio 5%).

Skin on anterior dorsal and dorsolateral surfaces shagreened with numerous small flat tubercles (Fig. 3A); tubercles small or pustules finely scattered and more prominent along the posterior sides of dorsum, sacral area, and dorsal surfaces of hindlimbs; dorsal surface of forelimbs smooth; upper eyelids smooth, supratympanic folds with low glandular ridges; ventral sides of trunk, head and limbs completely smooth (Fig. 3B); dorsomedial vertebral skin ridge weak, well discernible on the midline of dorsum and head.

Color of holotype in life: Dorsum reddish-gray on black tone, black markings mixed with small speckles densely scattered on dorsal surfaces of head, body, and limbs (Fig. 3A); posterior parts of dorsum and dorsal surfaces of hindlimbs with gray-brown pustules; canthus rostralis with narrow faded stripe formed by tiny flat tubercles;

Table 3. Measurements (in mm) and proportions of the type series of *Vietnamophryne vuquangensis* **sp. nov.**

Specimen ID	VNMN 010489 Holotype	VNMN 010488	VNMN 010490	VNMN 010498	VNMN 010517	VNMN 010518	VNMN 010519	VNMN 010520	VNMN 010521	VNMN 010528	VNMN 010491	VNMN 010492	VNMN 010487
Sex	M	M	M	M	F	F	F	F	F	F	F	F	F
SVL	14.91	14.12	14.85	14.12	16.48	17.33	15.64	15.49	16.69	15.72	16.67	15.15	15.51
HL	3.73	3.51	3.65	3.54	3.91	4.65	3.85	3.78	4.4	3.92	4.4	3.63	4.36
SL	2.09	1.95	1.94	1.79	2.1	2.18	1.99	1.91	2.13	1.99	2.1	2.03	1.88
EL	1.63	1.62	1.6	1.51	1.88	1.94	1.74	1.86	1.94	1.67	1.61	1.64	1.66
N-EL	1.03	0.99	1.01	0.85	1.15	1.24	1.06	1.08	1.07	1.04	1.14	1	1.07
HW	4.35	4.35	4.44	4.15	5.13	5.82	4.3	4.79	4.93	4.54	5.19	4.41	4.78
IND	1.48	1.47	1.54	1.24	1.69	1.74	1.51	1.62	1.53	1.5	1.59	1.49	1.51
IOD	1.87	1.97	2.16	1.71	2.06	2.13	1.93	1.8	1.9	1.84	1.89	1.84	1.91
UEW	0.92	0.85	0.91	0.8	1.11	1.34	0.91	0.91	0.93	0.85	0.88	0.78	0.79
FLL	8	7.66	7.73	7.79	8.83	8.71	8.86	8.54	8.99	8.61	8.5	7.91	8.99
LAL	6.2	5.67	5.77	5.75	6.41	6.29	6.64	6.22	6.87	6.28	6.47	6.02	6.24
HAL	3.34	3.03	3.01	3.16	3.66	3.52	3.52	3.1	3.67	3.24	3.29	2.98	3.53
IPTL	0.25	0.2	0.25	0.48	0.58	0.59	0.57	0.49	0.52	0.51	0.5	0.48	0.49
OPTL	0.32	0.25	0.31	0.56	0.62	0.67	0.63	0.59	0.61	0.65	0.62	0.56	0.59
HLL	22.84	20.99	22.43	22.2	24.72	23.53	24.71	24.23	25.39	24.07	24.31	23.74	23.29
TL	7.11	6.68	6.85	6.79	7.41	7.33	7.61	7.49	7.52	7.23	7.4	7.06	7.15
FTL	10.44	9.66	10.21	9.94	11.59	10.93	11.44	11.32	11.93	10.45	10.99	10.57	11
FL	7.06	5.87	6.59	6.47	7.69	7.15	7.14	7.39	8	6.86	6.88	6.76	7.57
IMTL	0.68	0.58	0.64	0.45	0.75	0.56	0.72	0.59	0.62	0.58	0.58	0.47	0.59
TYD	0.87	0.85	0.86	0.76	0.92	1.05	0.89	0.76	0.99	0.83	0.81	0.82	0.83
TED	0.62	0.64	0.68	0.59	0.64	0.74	0.67	0.65	0.64	0.68	0.55	0.68	0.71
1FLO	0.59	0.57	0.58	0.58	0.61	0.53	0.59	0.56	0.65	0.69	0.63	0.57	0.6
2FLO	1.31	1.17	1.28	1.36	1.31	1.11	1.32	1.18	1.38	1.41	1.34	1.14	1.35
3FLO	1.99	1.85	1.89	1.98	1.98	1.61	1.95	1.78	2.01	2.19	1.96	1.74	1.99
4FLI	1.29	1.09	1.18	1.13	1.04	1.06	1.07	1.04	1.26	1.24	1.06	1.09	1.16
1FW	0.22	0.16	0.22	0.2	0.22	0.27	0.22	0.22	0.22	0.23	0.27	0.18	0.22
2FDW	0.28	0.23	0.25	0.24	0.31	0.38	0.28	0.28	0.31	0.29	0.33	0.26	0.29
3FDW	0.3	0.26	0.3	0.31	0.39	0.41	0.39	0.38	0.36	0.31	0.36	0.3	0.3
4FDW	0.27	0.23	0.28	0.26	0.32	0.35	0.26	0.25	0.33	0.28	0.28	0.28	0.27
1TOEL	0.59	0.34	0.52	0.33	0.25	0.28	0.3	0.35	0.38	5	0.23	0.3	0.33
2TOEL	1.45	1.01	1.25	1.1	1.21	1.16	1.47	1.39	1.42	1.48	1.38	1.05	1.15
3TOEL	2.74	2.42	2.58	2.36	2.53	2.35	2.93	2.51	2.72	2.8	2.87	2.24	2.16
4TOEL	4.07	3.84	4.01	4.39	4.22	3.92	4.14	4.03	4.59	4.37	3.95	3.89	3.92
5TOEL	2.08	1.64	1.58	1.63	1.82	1.7	1.55	1.91	1.79	1.54	1.44	1.71	1.46
1TDW	0.25	0.25	0.25	0.3	0.23	0.26	0.19	0.2	0.4	0.22	0.18	0.23	0.21
2TDW	0.36	0.31	0.33	0.38	0.34	0.4	0.33	0.39	0.52	0.31	0.31	0.43	0.33
3TDW	0.39	0.38	0.39	0.43	0.43	0.43	0.35	0.45	0.56	0.4	0.48	0.55	0.38
4TDW	0.43	0.41	0.43	0.49	0.57	0.53	0.44	0.57	0.69	0.43	0.47	0.55	0.4
5TDW	0.38	0.36	0.38	0.35	0.4	0.38	0.33	0.35	0.34	0.35	0.33	0.44	0.37

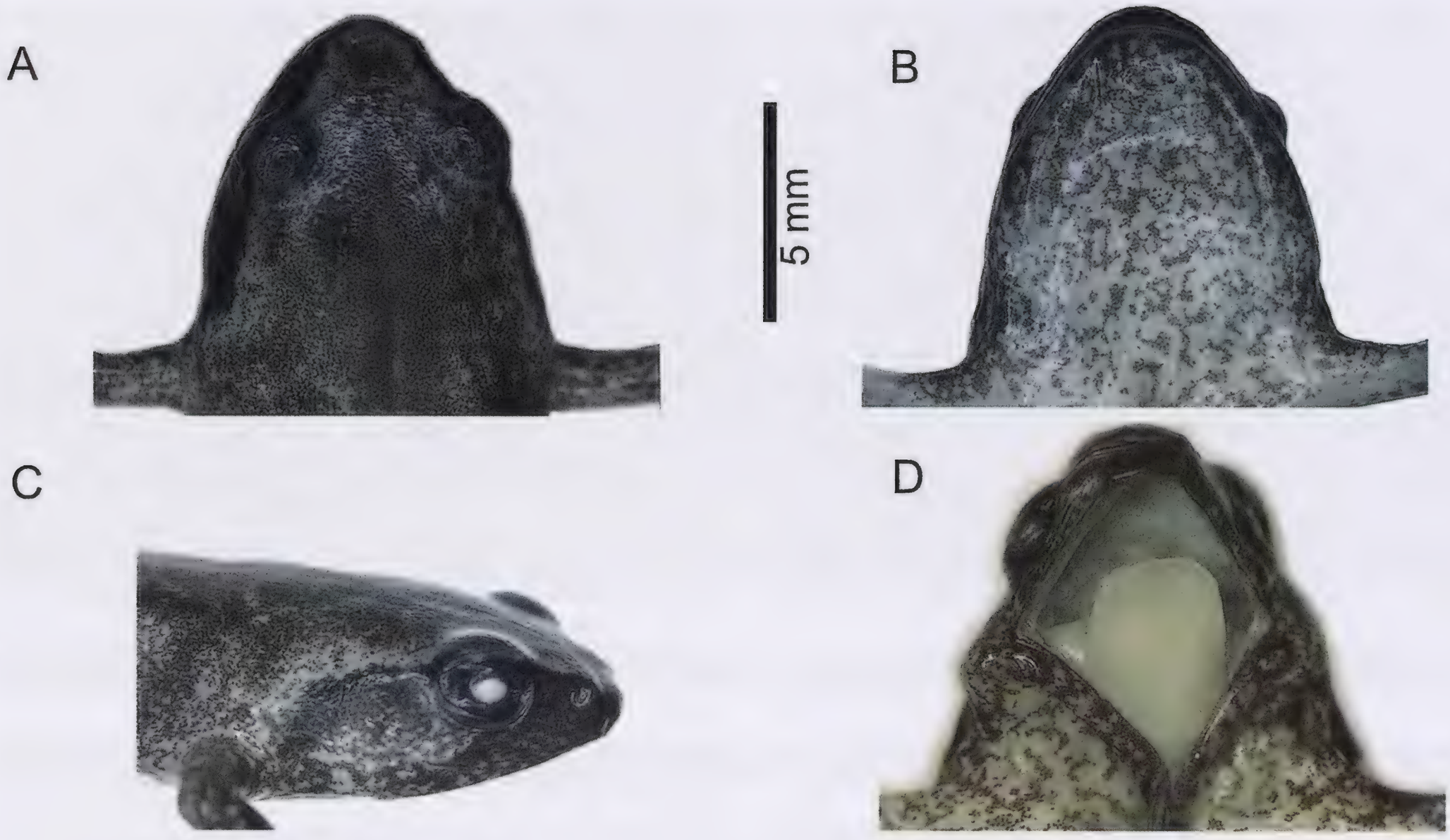

Fig. 4. Dorsolateral view of head (A), ventral view of head (B), lateral view of head (C), tongue (D), left hand (E), left foot (F), dorsolateral view (G) and ventral view (H) of the holotype (VNMN 010489) of *Vietnamophryne vuquangensis* **sp. nov.** in preservative.

loreal region dark with whitish mottling on lower jaw and mouth corners from snout tip toward eye along canthus rostralis (Fig. 3A); lateral sides of head dark brown with whitish mottling on upper jaw and mouth corners; white mid-dorsal line present, from near tip of snout to sacral area; dorsal surfaces of forearms orange-brown, interspersed with grey-brown; dorsal surfaces of hindlimbs reddish-brown with rare dark-brown tubercles and pustules; loreal region dark brown with whitish mottling; supratympanic fold with brick-red glandular tubercles with some whitish pustules; ventrally ivory-lemon with weak dark-brown marbling, more scarce on belly, denser on chest, throat, and ventral surfaces of limbs; fingers and toes dorsally gray-brown with indistinct reddish blotches, ventrally gray-brown with irregular beige or yellowish blotches (Fig. 3B). Pupil round, black, iris uniform dark brown (Fig. 3A)

Color of holotype in preservative: Dorsal surface changes to grayish-brown with white-gray spots made of rare dark-brown tubercles and collapsed pustules; underside of limbs, chin, and vent area grayish-white with denser dark-gray marbling. Underside of throat, chest and anterior portion of thighs white with scarce marbling (Fig. 4A, B).

Variation: The females have larger body sizes compared with males; dorsum reddish-gray on black ground in males and brownish-gray in females; tympanum distinct in females, relatively faint in males. The mid-dorsal line is well discernible in specimens VNMN 010492 and VNMN 010521, from near tip of snout to sacral area; mid-dorsal line absent in specimens VNMN 010487, VNMN 010491, VNMN 010517 to VNMN 010520, and VNMN 010528. For morphological variation see Table 1, and for color pattern variation see Fig. 5.

Etymology: The specific epithet is in reference to the type locality (Vu Quang National Park). We recommend "Vu Quang Dwarf Frog" as the common English name of the new species and the common name in Vietnamese as "Nhái lùn vũ quang".

Distribution and ecology: *Vietnamophryne vuquangensis* **sp. nov.** is currently known only from the type locality, Vu Quang NP, Vu Quang District, Ha Tinh Province. Specimens of the new species were found on the soil or under large tree-trunks and under leaf litter in evergreen tropical forests of Vu Quang NP at an elevation of 966 m a.s.l. (Fig. 6). The air temperature at the time of the finding was not recorded, but was 27°C at 19:40h. Other species of amphibians were found at night in the same habitat comprising *Microhyla mukhlesuri* Boulenger, 1884, *M.* cf. *heymonsi* Vogt, 1911, *Leptobrachium* cf. *chapaensis* (Bourret, 1937) and *Polypedates mutus* (Smith, 1940).

Comparisons: *Vietnamophryne vuquangensis* **sp. nov.** differs from *V. inexpectata*, *V. orlovi* and *V. occidentalis* by body size, dorsal skin, belly color, tympanum diameter, ratio snout length to eye length, ratio head width to head length and ratio first finger length to second finger (for details see Table 4). *Vietnamophryne vuquangensis* **sp. nov.,** having small body size, with SVL 14.12-14.91 mm in males (n=4), SVL 15.15-17.33 mm in females (n=9), can be distinguished based on size from the larger *V. orlovi*, with medium sized body, SVL 15.40 mm in the single known male individual, and *V. occidentalis*, with large sized body, SVL 20.5 mm in the single known male individual. The single known male individual of *V. inexpectata* has SVL of 14.2 mm. *Vietnamophryne vuquangensis* **sp. nov.** has warty skin in the dorsolateral fold area and is shagreened posteriorly with numerous small flat tubercles on the anterior dorsum (vs. warty skin on posterior and shagreened skin on anterior dorsum in *V. inexpectata*, vs. mostly smooth skin, slightly shagreened posteriorly, lacking enlarged tubercles in *V. orlovi*, and vs. mostly smooth skin with rare flat tubercles in *V. occidentalis*). *Vietnamophryne vuquangensis* **sp. nov.** ventrally is ivory-lemon to lemon-yellow with weak dark-brow marbling (vs. grayish-beige ventral coloration with gray marbling in *V. inexpectata*, vs. lemon-yellow belly with dark brown marbling in *V. orlovi*, and vs. bright orange-red belly with sparse dark brown marbling in *V. occidentalis*). *Vietnamophryne vuquangensis* **sp. nov.** has the F1 well developed, one-third of length of second finger (1FLO/2FLO 33-38%, 0.27-0.48 mm) and thus can be further distinguished from *V. inexpectata* having the F1 reduced to nub (1FL/2FL 29.6%). In *V. orlovi* it is well developed, half of length of second finger, (1FLO/2FLO 50%), and in *V. occidentalis* it is also well developed, less than half of second finger (1FLO/2FLO 42%). *Vietnamophryne vuquangensis* **sp. nov.** has the head length notably shorter than wide (HW/HL 117-124%, 110-131%) and thus can be further distinguished from *V. inexpectata* and *V. occidentalis* which have head length almost equal to head width, (HW/HL 101.1%) and (HW/HL 99.0%), and from *V. orlovi*, having head length longer than wide (HW/HL 86.5%). *Vietnamophryne vuquangensis* **sp. nov.** has the snout length longer than eye diameter (SL/EL 119-128%) and can be further distinguished from *V. inexpectata*, having snout length subequal to eye length, (SL/EL 96.8%), from *V. occidentalis*, having snout length shorter than eye diameter (SL/EL 85.5%) and *V. orlovi*, having snout length notably longer than eye diameter (SL/EL 139%). In having an in part deficient or faint, indistinct tympanum *Vietnamophryne vuquangensis* **sp. nov.** differs from *V. inexpectata* (TYD/EL 58%) and *V. orlovi* (TYD/EL 50%), having slightly larger tympanum, and from *V. occidentalis* (TYD/EL 40%), having slightly smaller tympanum. *Vietnamophryne vuquangensis* **sp. nov.** having eye to nostril distance twice as long as eye length (N-EL/EL 56-63%), and thus differs from

Fig. 5. Paratypes of *Vietnamophryne vuquangensis* **sp. nov**. (A) VNMN 010487, (B) VNMN 010491, (C) VNMN 010519, (D) VNMN 010518, (E) VNMN 010490, (F) VNMN 010521.

Table 4. Selected diagnostic characters for the species in the genus *Vietnamophryne*.

Species	*Vietnamophryne vuquangensis* **sp. nov.**		*V. inexpectata*	*V. orlovi*	*V. occidentalis*
	Male	Females	Male	Male	Male
Body size	14.12-14.91 mm	15.15-17.33 mm	14.2 mm	15.40 mm	20.5 mm
Skin of dorsum	Dorsal skin shagreened with small flat pustules loosely scattered on dorsum	Dorsal skin mostly smooth, slightly shagreened posteriorly, lacking enlarged tubercles	Dorsal skin shagreened anteriorly, distinctly warty posteriorly with large flat tubercles or pustules finely scattered on posterior dorsum	Dorsal skin mostly smooth skin, slightly shagreened posteriorly, lacking enlarged tubercles	Dorsal skin smooth, posteriorly with loosely scattered small flat tubercles present on surface of posterior dorsum
Belly color	ivory-lemon to lemon-yellow with weak dark-brown marbling	bright lemon-yellow with weak dark-brown marbling	grayish-beige with gray marbling	lemon-yellow belly with dark brown marbling	bright orange-red belly with sparse dark brown marbling
Tympanum	tympanum relatively faint, comparatively small, rounded, 5.4–6.0% of SVL	tympanum comparatively small, rounded, 4.8–6.2% of SVL	tympanum comparatively large, rounded, 7.9% of SVL	tympanum comparatively small, rounded, 5.5% of SVL	tympanum comparatively small, rounded, 5.0% of SVL
Snout length	snout comparatively long, rounded in dorsal and lateral views, snout length greater than eye length (SL/EL 119–128%)	snout comparatively long, rounded in dorsal and lateral views, snout length greater than eye length (SL/EL 100–130%)	snout short, obtuse in dorsal view, rounded in lateral view, subequal to eye length (96.8% of eye length)	snout comparatively long, rounded in dorsal and lateral views, snout length greater than eye length (SL/EL ratio 141.3%)	snout short, obtuse in dorsal view, rounded in lateral view, shorter than eye length (85.5% of eye length)
Head	Head wider than long, HW/HL ratio 117–124%	Head wider than long, HW/HL ratio 110–131%	head as long as wide, HW/HL ratio 101.1%	Head longer than wide, HW/HL ratio 86.5%	head as long as wide, HW/HL ratio 99.0%
Fist finger	Well developed, less than half of second finger (1FLO/2FLO 43-49%)	well developed, less than half of second finger (1FLO/2FLO 44-50%)	Reduced to nub, less than one-third of second finger (1FLO/2FLO 30%)	well developed, half of length of second finger (1FLO/2FLO 50%)	well developed, less than half of second finger (1FLO/2FLO 42%)

Fig. 6. Habitat of *Vietnamophryne vuquangensis* **sp. nov.** at the type locality in Vu Quang National Park, Ha Tinh Province, Vietnam.

V. orlovi by eye to nostril distance almost equal to eye length (N-EL/EL 111%). Eye to nostril distance in *V. inexpectata* (N-EL/EL 48.1%) and *V. occidentalis* (N-EL/EL 56%) is equivalent.

DISCUSSION

This study adds another new species to the only recently erected microhylid anuran genus *Vietnamophryne*. This highlights unpredicted species richness in *Vietnamophryne* and that probably further species will be discovered in other areas of Indochina, including central and northern Vietnam, Laos and northern Myanmar (see also Poyarkov *et al.,* 2018). Diversification within the genus *Vietnamophryne* was, most likely, a comparatively recent event due to the in part low genetic distances observed among species. Interspecific uncorrected p-distances of the *Vietnamophryne* species group were 3.1-5.1 in Poyarkov *et al.* (2018). We could extend the range from 1.9% (*V. occidentalis* vs. *V. orlovi*) to 5.8-6.2% (*V. orlovi* vs. *V. vuquangensis* **sp. nov.**) (Table 2). The new species of *Vietnamophryne* from Vu Quang NP differed clearly from all other group members in 16S rRNA sequences and it was most closely related genealogically to *V. inexpectata* from Kon Chu Rang NR (4.3-4.6%) This value was also distinctly higher than distances between *V. orlovi* and *V. occidentalis* (1.9%), as well as between *V. occidentalis* and *V. inexpectata* (4%). There is certainly more research required to have a better understanding of the genus *Vietnamophryne* and its interspecific distances and intraspecific variation range. The species of the genus *Vietnamophryne* are tiny, little-known frogs, with narrow range and habitats in the evergreen forests. Therefore, even the loss of a small part of the habitat can lead to a serious decline among *Vietnamophryne vuquangensis* representatives. Given the small distribution range known for *V. vuquangensis*, we propose an IUCN Red List status of Endangered.

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REFERENCES

Frost D. R. 2020. Amphibian Species of the World: An Online Reference. Version 6.0. Electronic Database accessible. Available from: http://research.amnh.org/herpetology/amphibia/index.html (accessed 28 February 2020).

Hall T. A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium* Series, 41 (1999): 95-98.

Hillis D.M & Bull J.J. 1993. An empirical test of bootstrapping as a method for assessing confidence in phylogenetic analysis. *Systematic Biology* 42: 182-192.

Huelsenbeck J.P. & Hillis D.M. 1993. Success of Phylogenetic Methods in the Four-Taxon Case. *Systematic Biology*, 42(3): 247-264.

Kumar S., Stecher G. & Tamura K. 2016. MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. *Molecular Biology and Evolution* 33(7): 1870-1874.

Leaché A. D & Reeder T. W. 2002. Molecular systematics of the eastern fence lizard (*Sceloporus undulatus*): a comparison of parsimony, likelihood, and Bayesian approaches. *Systematic Biology* 51: 44-68.

Nguyen T. T., Matsui M., Eto K. & Orlov N.L. 2014. A preliminary study of phylogenetic relationships and taxonomic problems of Vietnamese *Rhacophorus* (Anura: Rhacophoridae). *Russian Journal of Herpetology* 21(4): 274-280.

Poyarkov J. N. A., Vassilieva A. B., Orlov N. L., Galoyan E. A., Tran D., Le D. T. T., Kretova V. D. & Geissler P. 2014. Taxonomy and distribution of narrow-mouth frogs of the genus *Microhyla* Tschudi, 1838 (Anura: Microhylidae) from Vietnam with descriptions of five new species. *Russian Journal of Herpetology* 21(2): 89-148.

Poyarkov N. A., Suwannapoom C., Pawangkhanant P., Aksornneam A., Duong V. T., Korost D. V. & Che J. 2018. A new genus and three new species of miniaturized microhylid frogs from Indochina (Amphibia: Anura: Microhylidae: Asterophryinae). *Zoological Research* 38(3): 1-26.

Rambaut A., Drummond A.J., Xie D., Baele G. & Suchard M.A. 2018. Posterior Summarization in Bayesian Phylogenetics Using Tracer 1.7. *Systematic Biology* 67(5): 901-904.

Simmons J. E. 2002. Herpetological collecting and collections management. Revised edition. *Society for the Study of Amphibians and Reptiles, Herpetological Circular* 31: 1-153.

Suwannapoom C., Sumontha M., Tunprasert J., Ruangsuwan T., Pawangkhanant P., Korost D. V. & Poyarkov N. A. 2018. A striking new genus and species of cave-dwelling frog (Amphibia: Anura: Microhylidae: Asterophryinae) from Thailand. *PeerJ 6:*e4422. DOI: 10.7717/peerj.4422

Tanabe A.S. 2011. Kakusan 4 and Aminosan: two programs for comparing nonpartitioned, proportional and separate models for combined molecular phylogenetic analyses of multilocus sequence data. *Molecular Ecology Resources* 11: 914-921.

Tavaré S. 1986. Some probabilistic and statistical problems in the analysis of DNA sequences. *Lectures on Mathematics in the Life Sciences* 17: 57-86.

Thompson J. D., Gibson T. J., Plewniak F., Jeanmougin F. & Higgins D. G. 1997. The CLUSTAL_X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. *Nucleic acids research* 25(24): 4876-4882.

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A new species of *Garypus* (Pseudoscorpiones: Garypidae) from southern Thailand

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Abstract: A new pseudoscorpion species of the genus *Garypus*, *G. schwendingeri*, is described from a seashore habitat in southern Thailand.

Keywords: Taxonomy - description - seashore.

INTRODUCTION

The pseudoscorpion genus *Garypus* L. Koch, 1873 is widely distributed around the world, with 34 species occurring in seashore habitats (e.g. Beier, 1932, 1963; Chamberlin, 1921; Harvey *et al.*, 2020; Hummelinck, 1948; Lee, 1979; Muchmore, 1991). A recent taxonomic review of the genus *Garypus* in the Indo-West Pacific region by Harvey *et al.* (2020) recognised 14 species, including nine new ones. Many of these species are known from only single locations, suggesting that further species occur in the region.

Among the rich collection of pseudoscorpions from South-East Asia collected by Peter Schwendinger and his colleagues was a female *Garypus* specimen (Fig. 1) that did not match any of the previously described species. The opportunity is taken here to describe this new species, which represents the first *Garypus* species reported from mainland South-East Asia.

MATERIAL AND METHODS

The specimen examined for this study is lodged in the Muséum d'histoire naturelle, Geneva (MHNG). It was studied using a temporary slide mount prepared by immersion of the specimen in lactic acid at room temperature for two days, and then mounting it on a microscope slide with 10 mm coverslips supported by small sections of 0.25, 0.35 or 0.5 mm diameter nylon fishing line. After study, the specimen was rinsed in distilled water and returned to 75% ethanol, with the dissected portions placed in 12 × 3 mm glass genitalia microvials (BioQuip Products, Inc.). The specimen was examined with a Leica MZ-16A dissecting microscope and an Olympus BH-2 compound microscope and illustrated with the aid of a drawing tube attached to the compound microscope. Measurements were taken at the highest possible magnification using an ocular graticule. Terminology and mensuration mostly follow Chamberlin (1931), with the exception of the nomenclature of the pedipalps and legs, and with some minor modifications to the terminology of the trichobothria (Harvey, 1992), chelicera (Judson, 2007) and faces of the appendages (Harvey *et al.*, 2012). When expressed as a fraction, the numerator denotes the length and the denominator the width for all structures except for the legs where the denominator refers to the depth.

The following abbreviations are used for chelal trichobothria: FIXED FINGER: *eb*, externo-basal trichobothrium; *esb*, externo-subbasal trichobothrium; *est*, externo-subterminal trichobothrium; *et*, externo-terminal trichobothrium; *ib*, interno-basal trichobothrium; *isb*, interno-subbasal trichobothrium; *ist*, interno-subterminal trichobothrium; *it*, interno-terminal trichobothrium. MOVABLE FINGER: *b*, basal trichobothrium; *sb*, subbasal trichobothrium; *st*, subterminal trichobothrium; *t*, terminal trichobothrium.

TAXONOMY

Family Garypidae Simon, 1879
Subfamily Garypinae Simon, 1879
Genus *Garypus* L. Koch, 1873

Type species: *Garypus litoralis* L. Koch, 1873 (junior synonym of *Chelifer beauvoisii* Audouin, 1826), by subsequent designation of Simon (1879).

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Diagnosis: Species of *Garypus* differ from those of *Anchigarypus* Harvey in Harvey *et al.*, 2020, the only other genus of Garypinae, by the transverse or only slightly oblique suture between the metatarsi and tarsi of all legs (Fig. 9) (oblique in *Anchigarypus*), the absence of setae inserted within the pleural membrane (present in *Anchigarypus*), the presence of lateral spinules on the blades of the cheliceral rallum (absent in *Anchigarypus*), and the presence of microsetae near trichobothrium *b* (Fig. 8) (absent in *Anchigarypus*) (see Harvey *et al.*, 2020).

Garypus schwendingeri sp. nov.

Figs 1-10

Holotype: MHNG; female; THAILAND, Phuket Province, Siray Island, Cape Nga, 7°54'42.2"N, 98°26'06.7"E, 0 m (sea shore); 20-23.MAY.2003; leg. P. Schwendinger.

Etymology: This species is named in honour of Peter Schwendinger, collector of the holotype, and in recognition of his retirement as Curator of Arachnids at the Muséum d'histoire naturelle, Geneva.

Diagnosis: *Garypus schwendingeri* sp. nov. most closely resembles *G. dissitus* Harvey in Harvey *et al.*, 2020 in the following combination of character states: trichobothrium *st* closer to *sb* than to *t* (Fig. 6); tergites mostly pale yellow, with medial and lateral brown spots, and tergites III and IV mostly pale, with brown patches (Fig. 1); chelal fingers slightly curved in lateral view (Figs 4, 6); cucullus brown (Fig. 3). *Garypus schwendingeri* sp. nov. differs from *G. dissitus* by the rounded chelal hand which is only 1.05 times longer than broad (Fig. 5) (1.39 times in *G. dissitus*).

Description of female holotype

Color: Generally pale (Figs 1-3); carapace with anterior half brown, with brown lateral and medial markings; tergites pale yellow-brown, with brown lateral and medial markings; pedipalps yellow-brown, with dark brown chelae.

Setae and cuticle: Setae very small and straight; epicuticle waxy.

Chelicera: Surface slightly roughened; cheliceral hand with 5 setae; movable finger with 1 sub-distal seta; all setae acuminate; galea present, long, with 6 distal rami (Fig. 10); fixed finger with 6 small teeth, each approximately of same size; movable finger with 1 dorsal tooth and with 2 dorsal and 1 ventral lyrifissures; serrula exterior connected to chelicera finger for entire length, modified to form velum; serrula interior with 24 blades; lamina exterior present; rallum with 3 blades, each with anterior spinules; rallum with progressively shorter blades.

Pedipalp (Fig. 5): Long and slender, its surface very lightly granular; fixed chelal finger coarsely granular, movable chelal finger granular basally, remainder smooth; setae very small and slightly curved; trochanter with prolateral margin rounded, 1.67 times longer than broad; femur cylindrical, without dorsal tactile seta, 4.30 times longer than broad; patella cylindrical, pedicel not strongly pronounced but basal portion slimmer than distal portion, with several small lyrifissures situated basally on dorsal surface, 3.36 times longer than broad; chelal hand ovoid, retrolateral chelal condyle small and rounded, chela with pedicel 3.48 times longer than broad, chela without pedicel 3.34 times longer than broad, hand without pedicel 1.05 times longer than broad, movable finger 1.96 times longer than hand. Fixed finger with 8 trichobothria, movable finger with 4 trichobothria (Fig. 6): *eb*, *esb* and *isb* in straight row at base of fixed finger, *ib* and *ist* situated above and below that row, *it* closer to *et* than to *est*, *et* distal to *it*; *sb* on movable finger much closer to *b* than to *st*, *st* closer to *sb* than to *t*; both fingers curved in lateral view (Figs 4, 6). Surface of fixed finger granular, that of movable finger mostly smooth but granular basally. Chelal teeth juxtadentate; fixed finger with 81 triangular, retrorse teeth; movable finger with 78 triangular, retrorse teeth; accessory chelal teeth absent. Venom apparatus present in both chelal fingers, venom duct of medium length, terminating midway between *it* and *est* in fixed finger and basal to *t* in movable finger; nodus ramosus not inflated; without microsetae near *et*; with several microsetae near *b* and *t* (Figs 7-8).

Cephalothorax: Carapace (Fig. 3) sub-triangular; anterior margin medially indented; epistome absent; 0.98 times longer than broad; anterior and posterior furrows present; with two pairs of large, corneate eyes removed well back from anterior margin of carapace and situated on tubercle. Manducatory process with 4 apical setae and 22 additional setae; suboral seta absent; maxillary shoulder absent; median maxillary lyrifissure situated medially. Coxa I much wider than coxa IV; setae of coxae I-IV arranged 11: 10: 12: 27.

Legs: Femora I and II much longer than patellae I and II, respectively; femora I and II with primary slit sensillum directed transversely; junction between anterior femora and patellae perpendicular; junction between femur and patella of posterior legs strongly oblique (Fig. 9); femora III and IV much smaller than patellae III and IV, respectively; femur + patella IV 5.00 times longer than broad; tibiae, metatarsi and tarsi III and IV without tactile seta; metatarsi and tarsi of all legs not fused; metatarsi longer than tarsi; subterminal tarsal seta arcuate, acute; claws smooth; arolium shorter than claws, not divided.

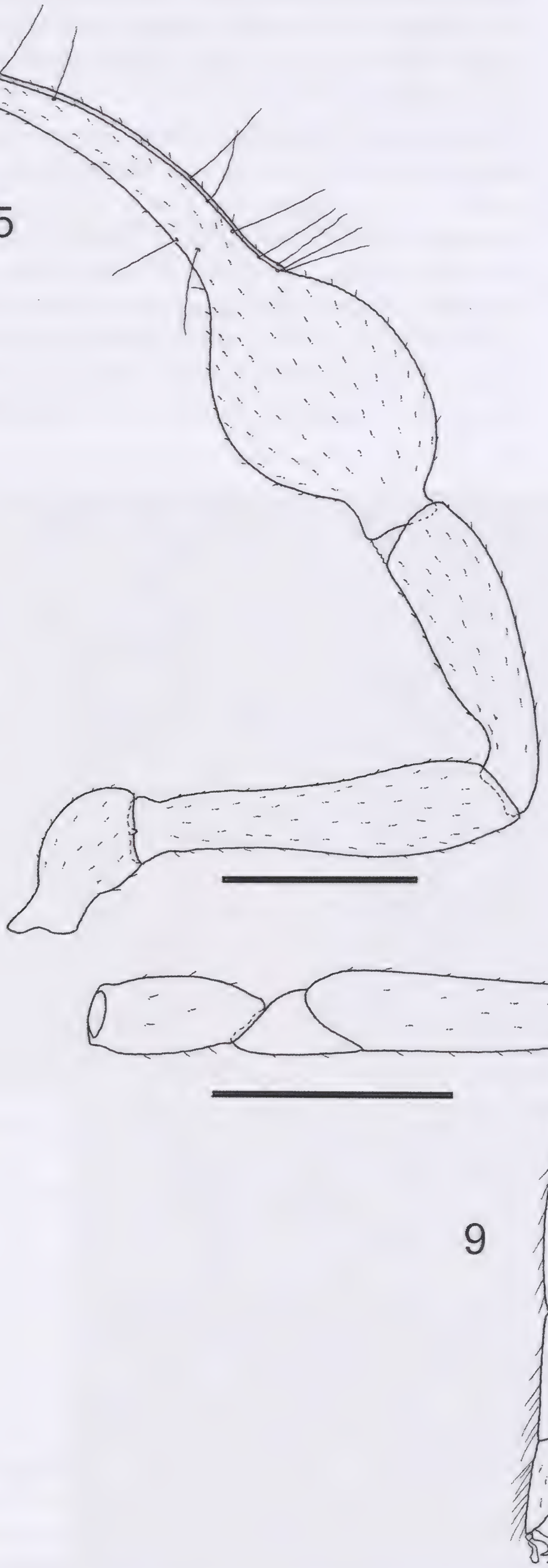
Abdomen: Tergites straight, divided; setal formula of tergites I-XII: 8: 10: 12: 14: 16: 16: 17: 15: 15: 12: 8: 2; setae arranged in single rows; setal formula of sternites II-XII: 20: (0) 7 (0): (0) 10 (0): 14: 16: 16: 15: 15: 12: 4: 2; setae of anterior genital operculum (sternite II) approximately same size as other sternal setae; posterior tergites and sternites without tactile setae; glandular setae absent; pleural membrane uniformly wrinkled plicate,

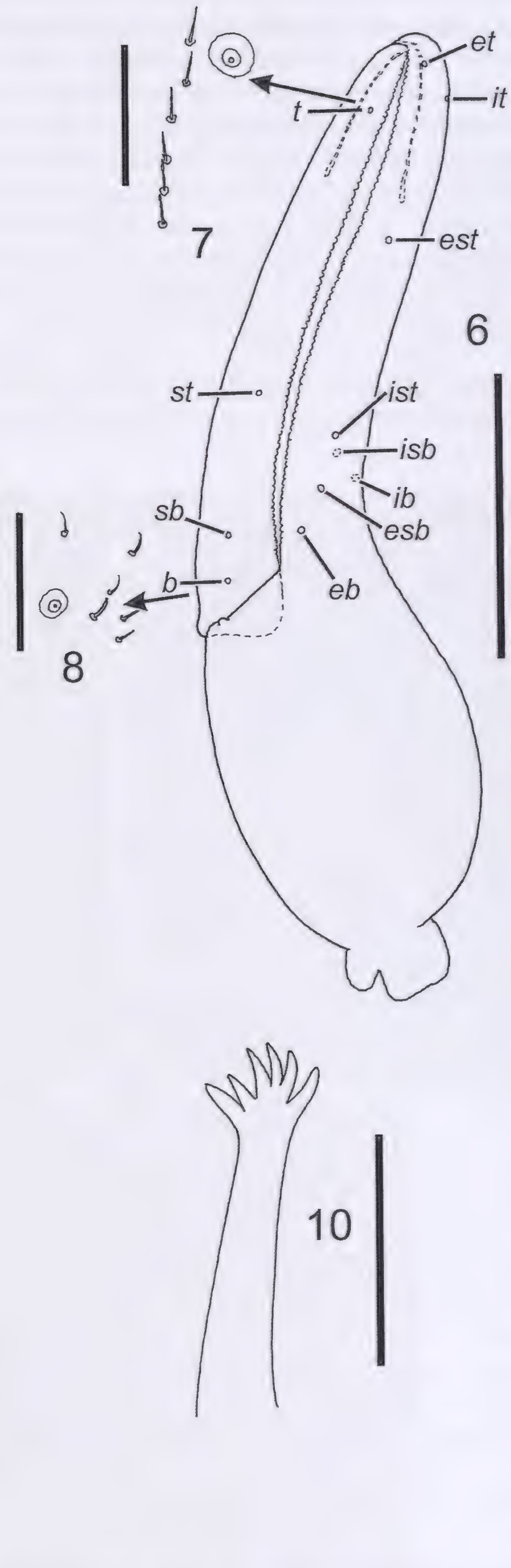
without setae; stigmatic sclerites without setae; stigmatic helix absent; anal ring (tergite XII and sternite XII) with raised rim, surrounded by sternite XI.
Genitalia: With 1 pair of lateral cribriform plates and 1 median cribriform plate divided into several smaller platelets.
Dimensions (in mm): Body length (excluding chelicerae) 6.34. Chelicera 0.555/0.265; movable finger length 0.325. Pedipalp: trochanter 0.825/0.495; femur 1.935/0.450; patella 1.615/0.480; chela with pedicel 3.375/0.970; chela without pedicel 3.240 long; hand without pedicel 1.105 long; movable finger length 2.170. Carapace 1.615/1.655; anterior eye 0.185; posterior eye 0.155. Leg I: femur 0.785/0.245; patella 0.520/0.250; tibia 0.655/0.180; metatarsus 0.460/0.130; tarsus 0.365/0.120. Leg IV: femur + patella 1.600/0.320; tibia 1.210/0.195; metatarsus 0.600/0.160; tarsus 0.430/0.140.

Remarks: The holotype and only known specimen of *G. schwendingeri* sp. nov. was collected on the seashore on Koh Siray in southern Thailand. The collector, Peter Schwendinger, informed me that although his field notes did not refer to the pseudoscorpion, the main collecting technique he used at the site was searching for arborial trapdoor spiders on tree trunks. Therefore, the specimen was most likely collected from the bark of one of the trees. The habitat was a tiny beach (only about 100 m long) with a few scattered mangrove trees in the water at high tide and a few coconut palms behind the narrow sandy beach.
The close morphological similarity between *G. schwendingeri* sp. nov. and *G. dissitus* highlights the possible origin of *G. dissitus* on Cocos (Keeling) Islands, assuming that the ancestor of *G. dissitus* had a South-East Asian origin. The Cocos (Keeling) Islands consist of a series of low coral islands with a maximum height of only five metres above sea level. They have only been above sea level for the past few thousand years when the sea approached its current level (Woodroffe *et al.*,

Figs 1-4. *Garypus schwendingeri* sp. nov., female holotype (before dissection). (1) Body, dorsal view. (2) Body, ventral view. (3) Cephalothorax, dorsal view. (4) Left palpal chela, lateral view.

1999). Therefore, the population of *G. dissitus* must have migrated from another landmass, of which the most likely candidates are the closest permanent islands, Sumatra and Java, some 1000 km away. The only *Garypus* species occurring in the vicinity of *G. schwendingeri* sp. nov. are *G. nicobarensis* Beier, 1930 on the Nicobar Islands and *G. yeni* Harvey in Harvey *et al.*, 2020 on the Krakatau Islands. However, *G. schwendingeri* sp. nov. and *G. dissitus* are quite dissimilar to these species, and most likely represent a different radiation.





Figs 5-10. *Garypus schwendingeri* sp. nov., female holotype. (5) Right pedipalp, dorsal view. (6) Left chela, lateral view, setae omitted. (7) Detail of *t* region, lateral view. (8) Detail of *b* region, lateral view. (9) Left leg IV, prolateral view. (10) Left galea, lateral view. Scale lines = 1.0 mm (Figs 5-6, 9); 0.5 mm (Figs 7-8); 0.1 mm (Fig. 10).

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REFERENCES

Audouin V. 1826. Explication sommaire des planches arachnides de l'Egypte et de la Syrie. *Description de l'Egypte ou recueil des observations et des recherches qui ont été faites en Egypte pendant l'expédition de l'armée française* 1(4): 99-186.

Beier M. 1930. Die Pseudoskorpione des Wiener Naturhistorischen Museums. III. *Annalen des Naturhistorischen Museums in Wien* 44: 199-222.

Beier M. 1932. Pseudoscorpionidea I. Subord. Chthoniinea et Neobisiinea. *Tierreich* 57: i-xx, 1-258.

Beier M. 1963. Ordnung Pseudoscorpionidea (Afterskorpione). Bestimmungsbücher zur Bodenfauna Europas 1. *Akademie-Verlag, Berlin,* vi + 313 pp.

Chamberlin J.C. 1921. Notes on the genus *Garypus* in North America (Pseudoscorpionida - Cheliferidae). *Canadian Entomologist* 53: 186-191.

Chamberlin J.C. 1931. The arachnid order Chelonethida. *Stanford University Publications, Biological Sciences* 7(1): 1-284.

Harvey M.S. 1992. The phylogeny and classification of the Pseudoscorpionida (Chelicerata: Arachnida). *Invertebrate Taxonomy* 6: 1373-1435.

Harvey M.S., Hillyer M.J., Carvajal J.I., Huey J.A. 2020. Supralittoral pseudoscorpions of the genus *Garypus* (Pseudoscorpiones: Garypidae) from the Indo-West Pacific region, with a review of the subfamily classification of Garypidae. *Invertebrate Systematics* 34: 34-87.

Harvey M.S., Ratnaweera P.B., Udagama P.V., Wijesinghe M.R. 2012. A new species of the pseudoscorpion genus *Megachernes* (Pseudoscorpiones: Chernetidae) associated with a threatened Sri Lankan rainforest rodent, with a review of host associations of *Megachernes*. *Journal of Natural History* 46: 2519-2535.

Hummelinck P.W. 1948. Studies on the fauna of Curaçao, Aruba, Bonaire and the Venezuelan Islands: no. 13. Pseudoscorpions of the genera *Garypus*, *Pseudochthonius*, *Tyrannochthonius* and *Pachychitra*. *Natuurwetenschappelijke Studiekring voor Suriname en Curaçao* 5: 29-77.

Judson M.L.I. 2007. A new and endangered species of the pseudoscorpion genus *Lagynochthonius* from a cave in Vietnam, with notes on chelal morphology and the composition of the Tyrannochthoniini (Arachnida, Chelonethi, Chthoniidae). *Zootaxa* 1627: 53-68.

Koch L. 1873. Uebersichtliche Darstellung der Europäischen Chernetiden (Pseudoscorpione). *Bauer und Raspe, Nürnberg*, 68 pp.

Lee V.F. 1979. The maritime pseudoscorpions of Baja California, México (Arachnida: Pseudoscorpionida). *Occasional Papers of the California Academy of Sciences* 131: i-iv, 1-38.

Muchmore W.B. 1991. Redescription of *Garypus viridans* (Pseudoscorpionida, Garypidae). *Caribbean Journal of Science* 27: 203-204.

Simon E. 1879. Les Ordres des Chernetes, Scorpiones et Opiliones. Les Arachnides de France 7. *Librairie Encyclopédique de Roret, Paris,* 332 pp.

Woodroffe C.D., McLean R.F., Smithers S.G., Lawson E.M. 1999. Atoll reef-island formation and response to sea-level change: West Island, Cocos (Keeling) Islands. *Marine Geology* 160: 85-104.

Appendix

ZooBank registration of new name:
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